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THE POPULAR Science Review

EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

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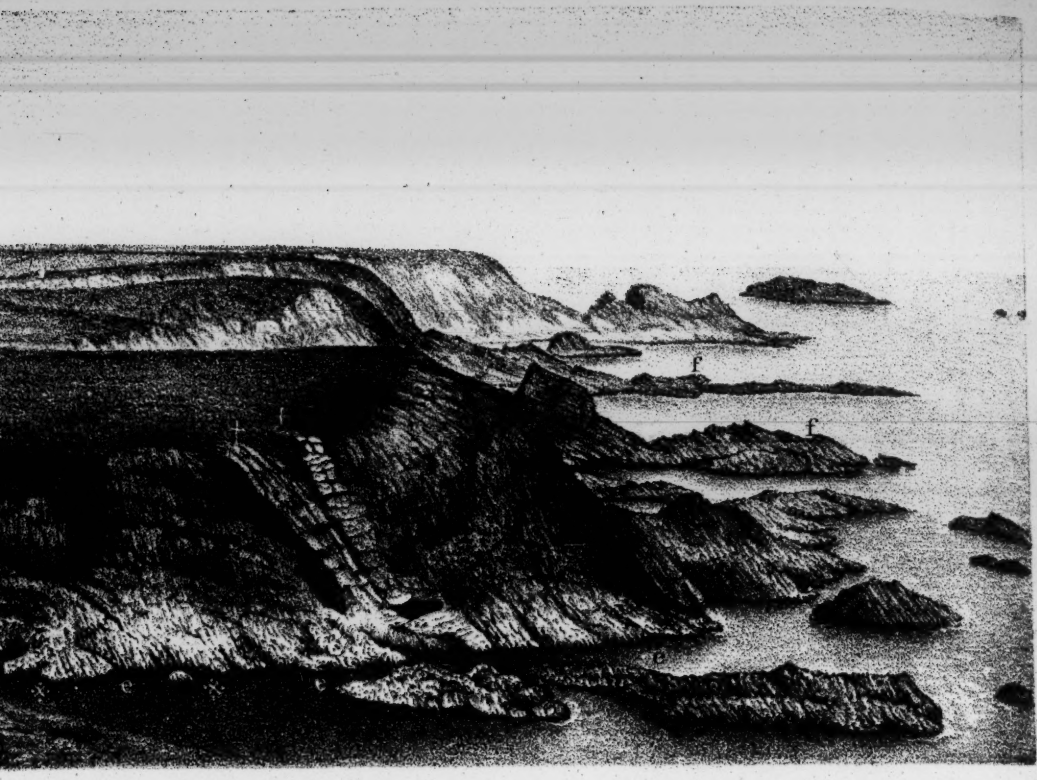

FIG 1. EAST SIDE OF PORTH-Y-RHAW.

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FIG. 2. COAST FROM PORTH-CLAIS TO CAERFAI.

THE CLASSIFICATION OF THE EOZOIC AND LOWER PALÆOZOIC ROCKS OF THE BRITISH ISLES.

By HENRY HICKS, M.D., F.G.S., &c.

[Plates VII. and VIII.]

THE additions which have been made to our knowledge in regard to the history and classification of the older rocks in Great Britain of late years have been very numerous, and yet but few attempts have been made to array them in systematic order, so that their importance may be readily recognized. The most elaborate account recently placed before the Geological world is the address of the President of the Geological Society (R. Etheridge, Esq., F.R.S.), published in the May number of the *Quarterly Journal*. An admirable paper, also, on a portion of these rocks, by Professor C. Lapworth, F.G.S., appeared in the June and July numbers of the *Geological Magazine* for this year.* In the present paper I propose to give a brief connected statement of the present state of our knowledge of these rocks, and the classification which appears to me the most natural one. Some new names will, of necessity, have to be added to explain local subdivisions, but in regard to the larger formations the terms which have been generally used in my papers of late years appear at present to be sufficient to include all the rocks explored.

Part I.

Eozoic (Pre-Cambrian).

For the sake of uniformity in the names for the larger periods in geological chronology, I adopt here the term which

* See also papers by the Author, *Quart. Journ. Geol. Soc.* vols. xxxi., xxxiii., xxxiv., and xxxv.; *Proceedings Geol. Assoc.* vols. iii. and vii.; and *Geol. Mag.* Decade II. vols. iii. and vi.

has been used for some time by American authors for the rocks known under the several names of Pre-Cambrian, Archæan, or Primary. Possibly none of the names hitherto suggested can remain in the face of future discoveries; but as long as the term *Palæozoic* continues to be so universally used for the succeeding period, the term *Eozoic* is probably the best that can at present be applied to this more ancient one.

The Eozoic rocks in Britain have of late years received a considerable amount of attention, and much additional information concerning them has in consequence been obtained. Up to a recent period it was supposed that with the exception of a narrow strip along the north-west coast of Scotland and in the Hebrides, there was no satisfactory evidence of the presence of these primary rocks anywhere in Britain. Stratified crystalline rocks had been noticed in other areas, but these were almost universally placed among much more recent deposits, either on theoretical grounds or by misconceptions in stratigraphy. With the exception of careful stratigraphical work nothing has tended so much of late to advance our knowledge in regard to these early rocks, as the recognition of the fact that the metamorphism of great groups of strata does not take place so readily as was formerly supposed, and that it is now tolerably clear that some special conditions, such as do not appear to have prevailed to any great extent over the British areas since the Pre-Cambrian (Eozoic) period, were necessary to produce such results. The unravelling of the history of these primitive rocks is fraught with many difficulties, and in the absence of organic remains the correlation of the groups in different areas is seldom as satisfactory as could be desired. But that there are special characters present which tend to distinguish each important group over wide areas there can be no doubt; and when we look closely into these, and at the same time take note of any influence which local physical conditions may have exerted, we can generally arrive at a tolerably satisfactory correlation.

We now divide the Eozoic rocks which are exposed in the British areas into four distinct formations under the names of Lewisian, Dimetian, Arvonian, and Pebidian.

1. *Lewisian.*

The oldest stratified rocks apparently in this country are some gneiss rocks, found chiefly in the Hebrides and along the north-west coast of Scotland, also probably along the north-west coast of Ireland, and perhaps in the Malvern Hills in England. Many years ago Sir R. Murchison expressed the opinion that these gneiss rocks along the north-west coast of

Scotland were the oldest in Great Britain, and, as far as we know at present, this view seems to be correct. He at first associated them with the Laurentian rocks of Canada; but though this correlation is possibly correct, he yet wisely grouped them under the local name Lewisian, after the island of Lewis, where they are largely developed. Dr. Sterry Hunt and myself have at different times pointed out the presence of these rocks in Ireland, and Dr. Holl has done the same in the Malvern Hills. The special characters which distinguish this group may be said to be the prevalence of very highly crystalline rocks, usually massive granitic gneisses, with red felspar and hornblende as their chief minerals, and quartz and mica in small proportion only. The normal strike is about east and west, but it varies to north-west and south-east.

Though but little additional information in regard to these rocks has been recently obtained, we are now better able, in consequence of the very important discoveries made of late years in other Eozoic rocks of Britain, to realize their importance in the classification, as well as the value of the formation in relation to the early history of these islands.

2. *Dimetian.*

This formation, like the above mentioned, consists chiefly of highly crystalline gneissic rocks, the prevailing types, however, being the so-called granitoid rocks, made up largely of quartz with some pinkish or white felspar. Hornblende is much less abundant than in the Lewisian rocks, but mica is more frequently met with. It may be said to consist chiefly of acid types of rocks, whilst the former is made up mainly of basic types. Bands of limestone, hornblende, chloritic, and micaceous schists occur occasionally in this formation.

The name Dimetian was first given by me to the group of granitoid and gneissic rocks which had been discovered by the late Mr. Salter and myself, underlying the Cambrian rocks at St. David's, in Pembrokeshire. Since then many additional areas of these rocks have been found, and the formation has been shown to consist of several important groups. In each area certain general resemblances in mineral characters are found to prevail, and these, combined with the physical evidences of contemporaneous deposition, are all the aids we can expect to find in our attempt at correlating such ancient rocks in different areas. That such evidences are important also is clear if we recognize the fact that the rocks must have been for the most part deposited in successive layers of various materials, like the alternating sediments in more recent groups, and in each case under tolerably similar physical conditions; that they also must have suffered changes in propor-

tion to their age, and that the evidences of these changes, which could not have affected more recent deposits, are usually sufficiently well marked to be readily recognized.

I have described rocks belonging to this formation in Anglesey, Caernarvonshire, and many parts of Scotland; and Prof. Bonney and Dr. Callaway have noticed them in Shropshire.

The series may be advantageously divided into Upper and Lower groups: the Upper represented by the so-called quartz schists of Porthlisky, St. David's, and probably by the thin quartzose gneisses and mica schists of Gairloch and Ben Fyn, Scotland; and the Lower, by the massive granitoid and gneissic rocks of Bryn-y-Garn, St. David's, and Twt Hill, Caernarvon, and probably also of parts of Ben Fyn and the mountains at the head of Loch Shiel in Scotland. I propose for the groups the local names Porthlisky and Bryn-y-Garn.

The prevailing strike in the formation is from N.W. to S.E.

3. *Arvonian.*

This name was given by me in 1878 to a group of rocks, in some important particulars unlike the Dimetian, though up to that time it had been included in that formation. Subsequent researches in North and South Wales have revealed the fact that this is one of the most important of the Pre-Cambrian formations. In Pembrokeshire it occupies large areas (see Sect. 2 and 3, p. 308), and is there found to consist mainly of highly siliceous rocks, of the type called by the Swedish geologists 'hälleflinta.' Breccias, quartz-felsites, and other quartzo-felspathic rocks, also enter largely into its composition. In Caernarvonshire, as I have shown in previous papers, many important ridges, such as the Rivals, and those to the north and south of Llyn Padarn, and between Twt Hill, Caernarvon, and Bangor, consist almost entirely of rocks belonging to this formation. In Anglesey, I pointed out in 1878 an area of these rocks near Ty Croes. This I have since found, in company with Prof. Hughes, to extend much further to the north than I at first supposed, in fact as far as Bodafon Mountain. At the latter place the 'hälleflintas' are perhaps better exposed, and more nearly of the type of those in Pembrokeshire, than in any other place in North Wales.* In my former paper I mentioned, in describing the Pebidian rocks of the west coast of Anglesey, that 'possibly some, such as the rocks of Holyhead Mountain may prove to be of different age and probably older

* Since I examined these rocks with Prof. Hughes, Prof. Bonney, in an appendix to an interesting paper by Dr. Callaway (*Quart. Journ. Geol. Soc.*, May 1881), has published some notes on these rocks which seem to confirm the above view. They are, however, called by him 'Quartz-schists.' In Dr. Calloway's map much too small an area is given to these rocks.

(Dimetian?)' I have since then carefully re-examined these rocks, and have come to the conclusion that they should be included rather with the Arvonian. Whether they occupy a higher or a lower, or an equivalent position to those of Bodafon Mountain, it is difficult at present to decide. Still the evidence seems to point to the quartz group at Holyhead being the highest. At St. David's, rocks like those of Holyhead exposed near Llanhowel are, I believe, higher in the succession than the more typical 'hälleflintas' of Treffgarn Rock. The strike is usually somewhere near north and south. This formation may be divided into two groups under the names of Treffgarn and Holyhead.

4. *Pebidian.*

This is a formation undoubtedly of enormous thickness, as may be seen from its partial exposure at St. David's (Sect. 1, p. 308), and contains several groups of rocks, in some respects considerably unlike each other. At present, however, it may be sufficient to divide the formation into two main groups. The lower one consists of the thin-bedded gneissic, micaceous, and talcose rocks; and the higher, of the brecciated rocks with their associated schists and slates. At St. David's the lower group is either but partially exposed or cut off by a fault. Some of the beds may be seen at Porthlisky Harbour resting unconformably upon the Dimetian axis. These are rather highly felspathic; others are the so-called talcose rocks, found frequently at this horizon in Canada, and described by Dr. Sterry Hunt as the 'commonly called talcose or nacreous schists, owing their peculiar characters to a soft, hydrous mica, which is not unfrequently disseminated in very quartzose beds and gives to such a schistose character.' Exactly similar rocks to these at Porthlisky occur at Dulas Bay, on the north coast of Anglesey; and I believe it will be found that they occupy a low position in relation to the chlorite-schists so well developed in that island. That the chlorite-schists in Anglesey, with a general north-east and south-west strike, belong to a period in the history of the globe not far removed from that indicated by the Lower Pebidian rocks of St. David's, I feel convinced. The deposits are sufficiently alike in material and in the changes they have undergone to be correlated. That they should now appear to be rather too much altered for this period, is probably due to the readiness of the chief materials entering into their composition to undergo change as compared with those in many of the other rocks. The view put forward by Sterry Hunt and Delesse, that 'talcose and chloritic rocks have been directly formed from the molecular re-arrangement or *diagenesis* of aqueous magnesian sediments,' seems to be the correct one, and to be capable of explaining many of the ap-

parent difficulties in connexion with these old rocks. That some of these chlorite and talc schists occur at various other horizons in the Pebidian, alternating with clay slates, quartz rocks, breccias, and conglomerates, is beyond doubt; and I may mention as spots where these alternations may be well observed, the valley of St. David's, north of the Cathedral, Treginnis, near St. David's, where they occur, as in Anglesey, in association with serpentinous limestone, and Amlwch in Anglesey. It is certain, therefore, that though the larger portion of the Anglesey schists may belong to the lower group of the Pebidian, they are not restricted to that horizon. This partial metamorphism, visible chiefly in rocks most susceptible of change, is highly characteristic of the Pebidian formation wherever it is exposed in Britain. It is sufficiently marked to separate the formation clearly from the succeeding Cambrian; and, on the other hand, it is too imperfect to cause any confusion between the majority of the rocks in this formation and the more completely crystalline groups belonging to the Dimetian or Lewisian.

The upper group is largely made up of brecciated rocks alternating with purplish, reddish, and greenish slates and schistose rocks. Indurated volcanic ashes, lava-flows, and bands of limestone and serpentine occur in both. It may be well to designate these groups by local names, and I propose therefore to call the upper the Treginnis group from being largely exposed at that place, on the shore of Ramsey Sound, near St. David's; and the lower, the Menai group, after the Menai Straits, where they are well displayed. The prevalent strike in this formation is from north-east to south-west.

This formation occurs in many parts of Scotland, especially in the Grampians; and it is also found, according to Dr. Hunt, in the north-west of Ireland, about Lough Foyle. It occurs also in Charnwood Forest, in Shropshire, in the Malvern Hills, and probably also in Cumberland and in Cornwall. The following table will explain the supposed order in which the Eozoic rocks occur in this country:—

Period.	Systems or Formations.	Groups.	Chief Petrological Characters.	Chief Localities where exposed.
Eozoic.	Pebidian.	Treginnis .	Conglomerates, Breccias, Schists, and Slates. Contemporaneous Lava Flows and Volcanic Ashes. Limestones and Serpentines.	St. David's, Anglesey, Caernarvonshire, and Harlech Mountains in Wales. Fort William and Grampians in Scotland. Lough Foyle, Ireland. Charnwood Forest, Wrekin, Malvern, &c.
		Menai . .	Breccias, Chloritic, Talcose, Felspathic, and Micaceous Schistose Rocks. Limestones and Serpentines.	St. David's, Anglesey, and Lleyn Promontory, Caernarvonshire. Grampians in Scotland.
	Arvonian.	Holyhead .	Schistose and Compact Quartz Rocks.	Llanhowell, near St. David's, and Holyhead Mountain in Anglesey.
		Treffgarn .	Breccias, Hälleflintas, and Quartz Felsites.	Treffgarn Mountain, Roch Castle and near St. David's in Pembrokeshire, Bodafon Mountain and Ty Croes in Anglesey, and several ridges in Caernarvonshire.
	Dimetian.	Porthlisky	Highly Quartzose Gneissic Rocks, with Limestone Bands.	Porthclais and Porthlisky near St. David's, Anglesey, and North-western Highlands of Scotland.
		Bryn-y-garn	Granitoid and Gneissic Rocks. Usually of a white, light grey, greenish, or pinkish colour.	St. David's and Brawdy in Pembrokeshire, Twt Hill, and Rhos Hirwain, Caernarvonshire, Anglesey, and North-western Highlands of Scotland.
	Lewisian.	. . . . .	Massive Hornblendic Gneiss, with but little Quartz or Mica. Of a black, dark grey or rusty colour.	The Hebrides and North-west Coast of Scotland, North-west of Ireland, and Malvern Hills in England.

Part II.

Lower Palæozoic.

It is not intended to burden this paper with a long history of the various classifications which have been adopted for these rocks from time to time; for classifications must necessarily vary with advancement of knowledge. All hard and fast lines, or the slavish adherence to any arrangement founded only in history and not in truth, are here, as in all other matters, barriers to progress. Numerous papers, however, on the question of history have of late been published, to which the reader may refer.*

The nomenclature will of necessity in some cases have chiefly a local significance, but as many of the groups have been at present little more than locally examined, this is almost unavoidable. Many of the names, however, are somewhat historical in their application, and have been so frequently used that they are now tolerably well known. The formations to be described are the Cambrian, Ordovian, and Silurian.

1. *Cambrian.*

Wherever these rocks are found in this country in contact with the Eozoic formations, they are unconformable to the latter. Fragments of the older rocks are also found in them in abundance, and evidence that they must have been built up chiefly from the denudation of the Eozoic rocks is everywhere apparent.

The name Cambrian, for these oldest Palæozoic rocks, was first used by Prof. Sedgwick, and it was he who laid the foundation for all future discoveries in these rocks. It is impossible to speak too highly of the value of his researches amongst these at that time barren strata; and if we cannot at present accept fully the divisions, or subdivisions, which he proposed, we reject them with much regret, and because their retention would greatly tend to retard the progress of science.

This formation may with advantage be divided into two main portions, with several groups in each.

The *Lower Cambrian* has a natural base made up of massive conglomerates and sandstones (see Sect. 1, p. 308); its upper boundary is well defined by an important palæontological break. It is

* See Hunt, *Canadian Naturalist*, 1872, and *Geol. Essays*, 1878; Etheridge, *Quart. Journ. Geol. Soc.* May, 1881; Marr, *Geol. Mag.* June 1881; Lapworth, *Geol. Mag.* June and July, 1881; and Hicks, *Proceedings Geol. Assoc.* 1873, *Quart. Journ. Geol. Soc.* 1875, and *Geol. Mag.* 1876.

FIG. 3. EAST SIDE OF CAERBWDDY HARBOUR.

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FIG. 4. NORTH COAST OF WHITESAND BAY.

clearly divisible—at St. David's, where it has been chiefly explored of late years—into three groups. These are called in ascending order by the local names of Caerfai, Solva, and Menevian (*c*, *d*, *e*, in Sections and Plates).

The *Caerfai group* consists chiefly of conglomerates, sandstones, and red, purple, and green slates and shales. Remains of animal life are found throughout. The most important of these were discovered by me, in 1868, in red slates, near the base, and consist of a *Lingulella*, *Discina*, *Leperditia*, a doubtful head of a trilobite, and abundant traces of annelids.

Beds of the same age are also found in the Harlech Mountains. The great slate quarries of Llanberis, Bethesda, and other places in Caernarvonshire, are also on this horizon. Though the basal beds are not exposed in the Longmynd area, it is probable also that some belonging to this group occur there. There is a strong general resemblance between the beds of this group in each of the areas, but as they were at first shore-deposits around a subsiding land-area, some differences in appearance and in thickness must necessarily occur. The great conglomerates which rest on the Eozoic rocks along the north-west coast of Scotland, are supposed to be of Lower Cambrian age, and may possibly be to some extent contemporaneous deposits with the beds of this lower group at St. David's. This group may be conveniently divided into three parts as under:—

Caerfai Group.	Upper, 1000 ft.	Purple Sandstones with *Annelids*, &c.
	Middle, 50 ft.	Red Shales and Schists, with *Leperditia cambrensis*, *Lingulella primæva*, *Discina caerfaiensis*, &c.
	Lower, 520 ft.	Conglomerates and Greenish Flaggy Sandstones with *Annelids*, *Fucoids*, &c.

Solva group.—Like the underlying Caerfai group, this may be also divided into three parts. The lowest beds are yellowish sandstones, with some conglomerates, and these are succeeded by grey flags. The latter contain an important fauna which I discovered in 1867. It consists of several trilobites, including the genera *Plutonia*, *Paradoxides*, *Conocoryphe*, and *Microdiscus*, also a *Lingulella*, *Theca*, and *Protospongia*. The species are all restricted to this horizon, and the genus *Plutonia* has not been discovered elsewhere as yet. The middle portion of this group consists of red, purple, and grey grits, sandstones, and slates; it is of great thickness, and probably contains several fossiliferous horizons. At present, though fragments have been found in several different beds, the only position in which they appear to occur in any abundance, is towards

the upper part of the series; here are found new species of *Paradoxides* and *Conocoryphe*, as well as fragments of several other fossils. Numerous markings are seen also on the surfaces of these and the underlying beds, similar to those described by Dr. Torell from Scandinavia, under the name of *Eophyton*. These were supposed by him to be land plants. Besides these numerous large so-called fucoidal markings are also frequently found. Whether any of these can be safely attributed to land or marine plants, must still be a matter of doubt, as no indications of true structure have been found in them. The upper beds of this group are grey grits and flags, and these also contain a special fauna. There can be no doubt that the Solva group represents the main portion of the Harlech-grit series as known in Merionethshire, and also probably of the Longmynd rocks. That there are some beds in those areas which may be considered contemporaneous with the Caerfai group, is, as I have already stated, probable; but I believe that the St. David's area was depressed at an earlier epoch than either of those, and therefore that it probably contains a series unrepresented there. I am inclined to think, however, that the lower beds of green grits and slates at Llanberis are nearly on the horizon of the Lower Caerfai rocks at St. David's. The rocks at Bray Head, in Ireland, appear to be more nearly contemporaneous with the Solva group than with the earlier beds. The St. David's fossils have not as yet been discovered in any of the other areas. Annelids and a doubtful trilobite, *Palæopyge*, were, however, found years ago by Mr. Salter in the Longmynd rocks; and annelids and the curious fossil, Oldhamia, have been found in the Bray-Head rocks.

Solva Group.	Upper, 150 ft.	Grey Rocks, with *Paradoxides aurora*.
	Middle, 1500 ft.	Grey, purple, and red Rocks, with *Paradoxides solvensis*, *Conocoryphe solvensis*, &c.
	Lower, 150 ft.	Yellowish Grits, Sandstones, and Flags with *Paradoxides Harknessii*, *Plutonia Sedgwickii*, and also *Eophyton*, large Fucoids, &c.

Menevian group.—This name was given by the late Mr. Salter and myself in 1865, to a series of beds found to contain a very important fauna new to this country at St. David's. Though there is a gradual passage from the beds of the Solva group into these (as shown in Sect. 1, p. 308, and in Pls. VII. and VIII.), in general appearance the rocks differ considerably from those in the other Lower Cambrian groups. This may be due to the combined influence of deeper water, and the presence of a greater abundance of animal and vegetable life; the

finer material to the former, and the dark colour to carbon and other substances derived from the latter. Though not of great thickness, the group is yet divisible into three well-marked zones, with distinct species in each. The genus *Paradoxides*, of which so many species occur in the Lower Cambrian rocks, does not in this country reach into higher beds than this group; and by it as well as by several other forms (*Anopolenus*, &c.) the Lower Cambrian is palæontologically well marked off from the Upper Cambrian. There is also an indication of some slight physical change at the close of the Menevian, in the sudden appearance of thick grit beds upon very fine muddy deposits. This is partially shown in the view (Pl. VII.) taken of the east side of Porth-y-rhaw, the place where the group was first made out. Whether this change had anything to do with the disappearance of *Paradoxides* and its allied genera or not, is difficult to make out. It was, at any rate, sufficiently important to have produced identical results in North Wales at the same time, for the upper beds are there, as in South Wales, capped by these massive sandstone beds. This group is everywhere distinct from, and should not be included in, the so-called Lower Lingula flags.* The fauna belonging to this group consists of twenty-three genera, including fifty-two species, and nearly all the species are restricted to it; the range of many is limited to a few beds. This group has been discovered at several places in Merionethshire, and contains there most of the characteristic fossils found by us at St. David's. It is there seen to rest on the well-known Harlech grits, and to be succeeded by Lower Lingula flags.

Menevian Group.	Upper, 100 ft.	Sandstones and Shales, with *Orthis Hicksii*, &c.
	Middle, 350 ft.	Flags and Slates, with *Paradoxides Davidis*, &c.
	Lower, 300 ft.	Grey Flags, with *Paradoxides Hicksii*, &c.

The views, Pls. VII., and VIII., figs. 1–3, show tolerably well the succession, and some of the chief sections of the Lower Cambrian rocks on the north shore of St. Bride's Bay, near St. David's.

The *Upper Cambrian* consists of four groups. The three lower ones were carefully described by the late Mr. Belt in 1867,† and named by him, in ascending order, Maentwrog, Ffestiniog, and Dolgelly groups (*f*, *g*, *h*, in sections and plates).

* It was by mistake that Mr. Etheridge, in the admirable address already referred to, included *Paradoxides* and some other Menevian genera in the Lower and Upper Lingula flag faunas.

† *Geol. Mag.* 1867 and 1868.

These had been partially described previously by Sedgwick and Salter, as Lower, Middle, and Upper Lingula flags. The fourth, or highest, group, was named by Sedgwick, many years ago, 'Tremadoc,' and this name is still retained for that group.

Maentwrog group (Lower Lingula flags).—The lowest beds in this group are described by Mr. Belt as 'grey and yellowish grey, fine-grained pyritic flags, with hard felspathic bands and rusty partings.' Alternations of more arenaceous and gritty beds are not unfrequent, and beds of yellow-grey shale also occur; these are followed by bluish-grey slates and flags. The middle and upper beds also are chiefly flags and slates. At St. David's, the lower beds are thin, ribbony-looking, and much contorted; these are succeeded by dark iron-stained slates and bluish flags. The genus *Olenus* is the characteristic fossil in this group, and it and the Phyllopod crustacean *Hymenocaris* occur here for the first time. The group is divided into upper and lower series, as under:—

Maentwrog Group.	Upper, 1800 ft.	Slates and Flags, with *Olenus truncatus* and *Olenus cataractes*, &c.
	Lower, 700 ft.	Sandy and Slaty Beds, with *Olenus gibbosus*, *Agnostus pisiformis*, &c.

Ffestiniog group (Middle Lingula flags).—This is also divided into upper and lower portions. The lower consists of a series of slightly arenaceous and micaceous grey flags; these are succeeded by thick beds of yellowish-grey arenaceous flags containing hard felspathic layers. The beds in this group are usually easily recognizable, because of the thin alternations of hard and soft layers, and by their peculiar weathering.

Lingulella Davisii and *Hymenocaris vermicauda* are the chief fossils in the lower beds. The upper beds are chiefly blue-grey flags, and contain, besides the above-mentioned fossils, a *Conocoryphe* and a *Bellerophon*. The whole group is very barren of animal remains, and appears to have been deposited in shallow water. The well-known fossil, *Cruziana*, which is, I believe, an Alga, occurs abundantly near Bangor and in other areas in this group; and a large species of *Buthotrephis* was found in it by the late Mr. Belt.

Ffestiniog Group.	Upper, 50 ft.	Bluish-grey Flags, with *Conocoryphe bucephala* and *Bellerophon cambrensis*, &c.
	Lower, 2000 ft.	Arenaceous and Micaceous Yellowish-grey Flags, with *Lingulella Davisii*, *Hymenocaris vermicauda*, *Cruziana*, &c.

Dolgelly group (Upper Lingula flags).—This group consists mainly of blue and black slates. It was evidently deposited in a tolerably quiet sea, and contains a rich fauna. The beds are well exposed in the Mawddach Valley, and about Portmadoc in North Wales. The so-called Malvern black shales also belong to this group. At St. David's, fine grey shales chiefly occur at this horizon. The Olenoid forms, *Parabolina*, *Peltura*, and *Sphærophthalmus*, characterize this group.

Dolgelly Group.	Upper, 300 ft.	Soft Black Slates, with *Peltura*, *Sphærophthalmus*, &c.
	Lower, 300 ft.	Hard Blue Slates, with *Parabolina*, &c.

Tremadoc group.—This group consists mainly of dark earthy flags, flaggy sandstones, and iron-stained slates. It was carefully examined many years ago in North Wales, by Sedgwick, Salter, and Homfray, and shown to contain a very important fauna. Up to the year 1866, it had only been recognized in North Wales; but in that year I was able to announce the discovery at St. David's of a large series of fossils, more nearly allied to those in this group than to any others known. It has since been found in Shropshire by Dr. Callaway. About sixty species have now been discovered altogether, and nearly all are peculiar to the group. Many genera, and several orders, appear here for the first time in the succession. The Lamellibranchs, Crinoids, Asteroids, and Cephalopods, are not known to occur at a lower horizon, and several of these, as yet, have only been found at St. David's, in these rocks.

Tremadoc Group.	Upper, 800 ft.	Iron-stained Flags and Slates, with *Asaphus Homfrayi*, *Angelinia*, &c.
	Lower, 200 ft.	Dark Earthy Flags and Flaggy Sandstones, with *Neseuretus*, *Niobe*, &c.

2. *Ordovian* (*Lower Silurian*).

The name 'Ordovian,' has been given to this formation by Prof. Lapworth, who has paid great attention to its fossils, especially to the Graptolites, and these somewhat specially characterize the groups in the formation. I adopt this name now in preference to that of Lower Silurian, as less likely to lead to confusion, and as being in many respects an appropriate one. It consists of four well-marked groups, each with a distinct and important fauna. Three of these have been for a long time

well known, but the fourth (Llanvirn group) is now introduced for the first time, though its position has been partially defined in previous papers.* The groups are named, in ascending order, Arenig, Llanvirn, Llandeilo, and Bala.

Arenig group.—This name was first given by Prof. Sedgwick, to a group of rocks well developed in the Arenig district in North Wales. For many years, however, it yielded but few fossils, and its importance was scarcely suspected until after the discovery in it, at St. David's, of a very rich fauna. In a former paper I divided the group into lower, middle, and upper parts. I have since found that the upper, as there defined, is so distinct in its fauna from the underlying or middle part, and, indeed, at present so little known out of the neighbourhood of St. David's, that I have, at the suggestion of Prof. Lapworth, given it a local name, and will therefore describe it as a distinct group. The Arenig proper will, therefore, now be divided into two parts, upper and lower, the former being the portion previously described as the middle part. The group consists almost entirely of black slates, with, however, a few beds of flaggy sandstones, and in North Wales with some grits. Graptolites, which appear for the first time in the underlying Tremadoc rocks,† occur in this group in great abundance; the trilobites, also, are altogether unlike those in the underlying rocks. The evidence, therefore, of a palæontological break between the Cambrian and Ordovian, is tolerably clear, though stratigraphically it is not seen. The so-called 'Skiddaw slates' belong chiefly to the upper portion of this group. The graptolites hitherto collected in the lower portion are chiefly *Diplograpti* and *Cladophora;* in the upper, the genera *Tetragraptus* and *Didymograptus.*

Arenig Group.	Upper.	Slates, Flags, and Sandstones, with *Ægliua, Calymene,* &c.
	Lower.	Fine Black Slates and Shales, with *Ogygia, Trinucleus,* &c.

The view, Pl. VIII., fig. 4, shows the Arenig rocks at Whitesand Bay. A few beds of the Tremadoc group are also seen, but most of the beds of this group have been here cut off by a fault.

Llanvirn group.—As stated above, this group was described by me formerly as a portion of the Arenig (its position is seen in Sect. 2, p. 308). It consists of a thick series of

* Hicks, *Quar. Jour. Geol. Soc.* May 1875.

† Found by Dr. Callaway in Shropshire, and also by Mr. Homfray near Portmadoc.

dark slates and shales, with contemporaneous beds of volcanic tuff. It has an average thickness, as now defined, of about 2000 feet, and contains a distinct and important fauna. Most of the species are new, and amongst the trilobites is one genus (*Placoparia*) not elsewhere found in Britain. The fauna, which was worked out by me from the beds at Llanvirn, St. David's, in 1874, is very rich in trilobites; and several genera appear here for the first time in the succession, as *Illœnus*, *Illœnopsis*, *Barrandea*, *Phacops*, *Placoparia*, and *Acidaspis*. The fauna also contains many graptolites, chiefly of the genera *Diplograptus* and *Didymograptus*, and there are also large Cephalopods, Gasteropods, Brachiopods, and Lamellibranchs. Beds belonging to this group have been explored by Mr. Marr near Caernarvon; they are probably to be found also near Shelve, in Shropshire. The lower portion of the so-called Llandeilo at Abereiddy Bay belongs rather to this group than to the typical Llandeilo, and is here included in it. *Didymograptus Murchisonii* is supposed by Prof. Lapworth to be characteristic chiefly of these beds.

Llanvirn Group.	Upper.	Fine Black Slates interstratified with Beds of Tuff containing *Didymograptus Murchisonii*, &c.
	Lower.	Dark-grey Flags and Slates, with *Placoparia*, &c.

Llandeilo group.—In the typical area (Llandeilo), Sir R. Murchison described the rocks belonging to this group in ascending order, as dark schists and shales with sandstone courses, followed by calcareous grits and pebble beds, and succeeded by schists in which *Asaphus tyrannus* is conspicuous; upon these occur calcareous, dark-coloured, finely laminated flagstones and schists. This group as it occurs in Pembrokeshire, after excluding the lower beds which I propose now to place in the Llanvirn group, may be divided into two parts; the lower consisting of black calcareous shales and flags, followed by tolerably compact limestone; and the upper portion of black slates, flags, and flaggy sandstones. The beds are well exposed on the north shore of Abereiddy Bay, near St. David's (see Sect. 2, p. 308), and are there highly fossiliferous, *Ogygia Buchii*, *Calymene duplicata*, *Cheirurus Sedgwickii*, *Trinucleus fimbriatus*, occurring in abundance. The Glenkiln slates of Scotland are supposed by Lapworth to be the equivalents of the upper beds of this group.

Llandeilo Group.	Upper.	Black Slates, Flags, and Flaggy Sandstones, with *Ogygia Buchii*, &c.
	Lower.	Calcareous Shales and Flags, &c., with *Asaphus tyrannus*, &c.

Bala group.—The beds of this group are particularly well developed in the neighbourhood of Bala, N. Wales, therefore the name suggested by Sedgwick is peculiarly appropriate. The rocks have also been called by other authors by the name Caradoc, from the Caradoc mountain range in Shropshire, where they are also exposed. The group consists of sandstones, shales, and flags, alternating with calcareous bands and contemporaneous volcanic ash. It attains to a great thickness, but varies considerably in different areas in consequence of the presence of so much volcanic material. Of late years but little work has been done in this group in Wales, but in Scotland the researches of Prof. Lapworth have added considerably to our knowledge of the fauna. The fauna of the Bala group is an exceedingly rich one, especially in trilobites. Graptolites also occur in abundance, chiefly Diplograptidæ and Dicranograptidæ. Prof. Lapworth calls special attention* to the 'total distinction in palæontological features between the graptolite faunas of the Bala and Arenig' groups. 'In the true Bala beds not a single example of the families of the Dichograptidæ or Phyllograptidæ has hitherto been detected. So far as our present information enables us to judge, they appear to have become wholly extinct, and their place is occupied by the very distinct families of the Diplograptidæ and Dicranograptidæ.' It is important also to notice, as bearing on the physical history of this epoch, that the 'mortality in families, genera, and species of Rhabdophora in the Upper Caradoc (Bala) beds,' is very great. And that the palæontological break between this last member of the Ordovian formation and the overlying Silurian, so far as the Rhabdophora are concerned, is almost complete. The Hartfell shales of Scotland belong to this horizon.

Bala Group.	Upper.	Shales, Flags, and Limestones.
	Lower.	Sandstones and Shales, with Calcareous Bands.

* *Annals and Mag. of Natural History*, series 5, vol. iii.

3. *Silurian* (*Upper Silurian, Murchison*).

Though this name was intended by Murchison to include, perhaps, all the fossiliferous rocks below the Devonian, it has been quite evident for a long time that the restricted meaning in which it is here used is the only way to get rid of much confusion in geological nomenclature. The groups here included in it are, in ascending order, Llandovery, Wenlock, and Ludlow.

Llandovery group.—The name was given to this group by Sir R. Murchison in consequence of the great development of rocks of this age near the town of Llandovery, S. Wales. It is supposed to attain a thickness, there and in Pembrokeshire, of over 2000 feet; whilst it is well known that in some other areas in Wales it thins out to about as many hundred feet. The physical break between this group and the underlying Bala has been frequently referred to by Sedgwick, Ramsay, and others, and there can be no doubt that it is the most important one in the Lower Palæozoic rocks. To a great extent, however, it must be considered to have been produced by local influences. For whilst in the Longmynd and other areas there is ample evidence now to show that there was dry land at the time, there is equally convincing proof that marine conditions continued during the same period in Cardiganshire and Pembrokeshire. In Sect. 3, p. 308, the Lower Llandovery rocks rest conformably upon the Bala beds. The rocks which compose this group vary considerably in different areas, but may be said to consist chiefly of conglomerates, sandstones, shales, and slates. It is usually divided into lower and upper portions,—the latter being also called frequently the 'May-Hill Sandstone series.' The so-called 'Tarannon shales' and 'Denbighshire grit and flag series,' are probably on the horizon of the upper members of this group. In the last-mentioned series I have recently discovered the earliest indications of land-plant remains hitherto found in Britain. They are all in a fragmentary condition and must have been carried into their present positions from some neighbouring lands by floods. These beds have yielded to Prof. Lapworth, in Scotland, a rich fauna of Graptolites, the prevailing family in the lower beds being the Diplograptidæ, whilst in the upper beds the Monograptidæ are dominant.

Llandovery Group.	Upper.	Conglomerates, Sandstones, Shales, and Slates.
	Lower.	Conglomerates, Sandstones, and Shales.

Wenlock Group.—This group has a considerable thickness,

and is usually divided into an upper series, under the name of 'Wenlock limestone and shale,' and a lower by the name of 'Woolhope beds.' In North Wales the lower beds rest conformably on the Denbighshire grit and flag series. The Woolhope limestone is supposed to be only locally developed. The fauna of the group consists mainly of Crinoids and Corals; but Brachiopods occur also in great abundance, and numerous new species have been lately added to the fauna by the researches of Mr. G. Maw and Mr. Davidson. Mr. Maw estimates the thickness of the group in Shropshire at over 2500 feet. As previously stated, I exclude the typical so-called Denbighshire grit and slate series from the group, believing that those beds are for the most part on a lower horizon than any rocks usually included in this group in Shropshire.

Wenlock Group.	Upper.	Shale and Limestone.
	Lower.	Shale, Limestone, and Flaggy Beds.

Ludlow Group.—This group in Shropshire attains a thickness of from 1400 to 1800 feet. It consists mainly of dark grey argillaceous shales with calcareous concretions, and limestone. It is divisible, however, into two portions. The upper consisting of light-coloured grits and shales, and the lower of the 'Aymestry Limestone series.' The fauna of this group is important from its including the first indications of vertebrate life as fish remains. Until the discovery by me lately of the land-plant remains in the Denbighshire grit series; it was also supposed that the first evidences of a terrestrial flora occurred in these rocks. The fauna of this group for the most part is highly Silurian in type, but the topmost beds appear lithologically and palæontologically to be passage-beds connecting the Silurian and Devonian formations.

Ludlow Group.	Upper.	Shales, Flaggy Sandstones, and Grits.
	Lower.	Hard Flaggy Shales, with Bands of impure Limestone.

Table of British Lower Palæozoic Strata (1881).

			Petrological Characters.	Thickness of Strata.	Characteristic Types and Order of Appearance of Life.	Localities where exposed.
				Feet.		
Silurian (Sedgwick).	Upper Silurian (Murchison).	Silurian.	Ludlow Group	Grits, Sandstones, Shales, and Limestone	1800	Pisces	Ludlow, Ledbury, Downton, Kingston, Lesmahago, Whitcliffe, Malvern, Longhope, Aymestry, View Edge, &c.
			Wenlock Group	Shales and Limestone	2500	. . . . .	Wenlock Edge, Dudley, May Hill, Malvern, Llangollen, &c.
			Llandovery Group	Conglomerates, Sandstones, Slates, and Shales	160 to 2500	Plantæ (land plants) . . .	Llandovery, Haverfordwest, May Hill, Corwen, Tarannon, Birkhill, Girvan, &c.
Upper Cambrian.	Lower Silurian.	Ordovian.	Bala Group	Sandstones, Flags, Shales, and Limestone	4000 to 12,000	. . . . .	Bala, Caradoc Ridge, Horderly, Norbury, Snowdon, Haverfordwest, Wexford, Kildare, Hartfell.
			Llandeilo Group	Calcareous Shales, Flags, and Sandstones	3000	Actinozoa	Dumfriesshire, Llandeilo, Builth, Abereiddy Bay, &c.
			Llanvirn Group	Grey Flags and Black Slates	2000	. . . . .	Llanvirn and Coast of Abereiddy Bay, Ramsey Island, Shelve, &c.
			Arenig Group	Slates, Flags, and Sandstones	2500	Gasteropoda . . . . . Echinodermata (*Crinoidea*, *Asteroidea*)	Arenig, Shelve, Ramsey Island and and Whitesand Bay (St. David's), Skiddaw (Cumberland).
Middle Cambrian.		Upper Cambrian.	Tremadoc Group	Dark Slates and Flaggy Sandstones	1000	Hydrozoa (*Graptolites*). Lamellibranchiata and Cephalopoda .	Portmadoc, Ramsey Island and Whitesand Bay (St. David's), Shineton (Shropshire).
			Dolgelly Group	Soft Black Slates and Shales	600	Bryozoa (*Dictyonema*) . . .	Portmadoc, Dolgelly, Malvern, Whitesand Bay, &c.
			Ffestiniog Group	Grey arenaceous and micaceous Flags	2000	Heteropoda, Plantæ (marine-plants)	Maentwrog, Dolgelly, Malvern, Ramsey Island, Solva.
			Maentwrog Group	Slates, Flags, and Sandstones	2500	Crustacea (*Phyllopoda*) . . .	Maentwrog, Dolgelly, Solva.
Lower Cambrian.	Cambrian.	Lower Cambrian.	Menevian Group	Dark Slates and Flags	750	Echinodermata (*Cystidea*) . . Pteropoda	St. David's, Solva, Maentwrog, Dolgelly.
			Solva Group	Purple, Red, and Grey Grits, Flags, and Slates	1800	Crustacea (*Ostracoda*, *Trilobita*) .	Solva, St. David's, Harlech Mountains, Longmynd Range, Bray Head, &c.
			Caerfai Group	Purple, Green, and Red Sandstones and Slates, Conglomerates.	1600 to 4000	Brachiopoda, Protozoa, Annelida, Plantæ ?	St. David's, Whitesand Bay, Bangor, Llanberis, &c.

EXPLANATION OF PLATES VII. AND VIII.

Views from Photographs taken by E. H. Griffiths, Esq., M.A., F.G.S., and H. T. Hall, Esq., B.A.

Plate VII.

Fig. 1. View of the East side of Porth-y-rhaw to Cradle Rock, showing junction of Menevian and Maentwrog groups.

Fig. 2. View of the Coast from Porth-clais to Caerfai, showing Caerfai and Solva groups.

Plate VIII

Fig. 3. View of the East side of Caerbwddy Harbour, showing fault near junction of Caerfai and Solva groups.

Fig. 4. View of the North coast of Whitesand Bay, showing the Arenig rocks.

The small letters have the same signification as in the woodcut sections.

** Indicate the chief fossiliferous ocalities.

† Indicates intrusive rock.

F Fault.

Horizontal Scale about 1 inch to a mile; Vertical Scale

FIG. 1.—Section across St. David's Promontory

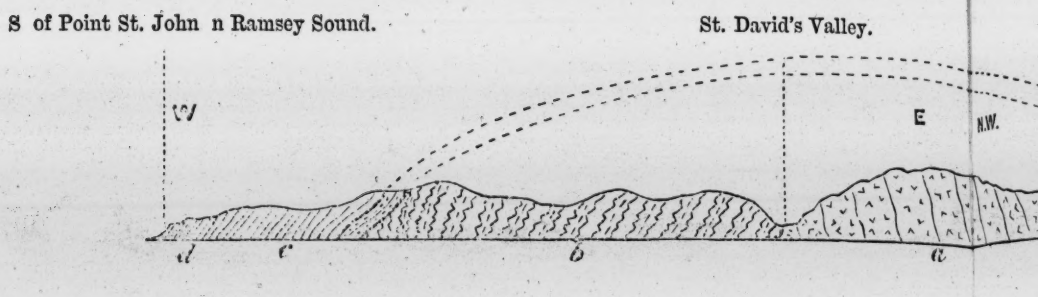


FIG. 2.—Section from the Coast near Solva to the Coast

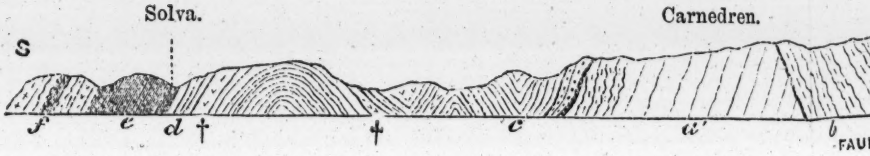
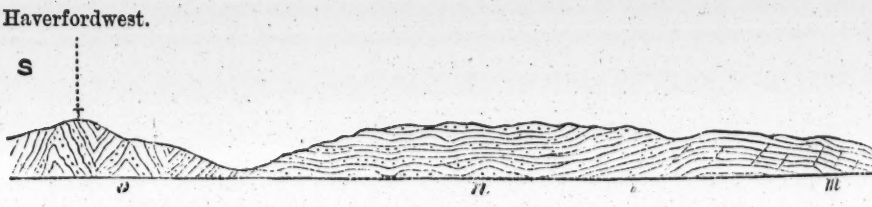


FIG. 3.—Section from Haverfordwest to the N. of the

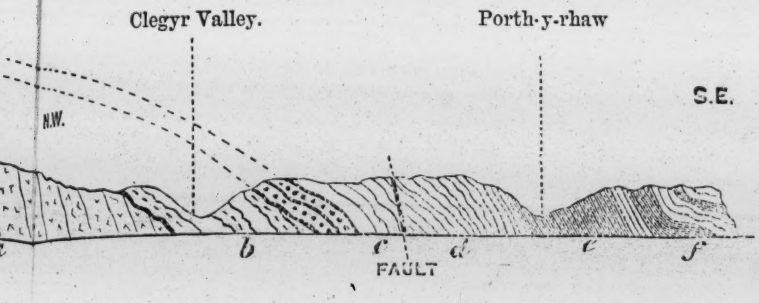


o. Llandovery Group		PALÆOZOIC (Lowest Groups).
n. Bala	,,	
m. Llandeilo	,,	
l. Llanvirn	,,	
k. Arenig	,,	
i. Tremadoc	,,	
h. Dolgelly	,,	
g. Ffestiniog	,,	
f. Maentwrog	,,	
e. Menevian	,,	
d. Solva	,,	
c. Caerfai	,,	

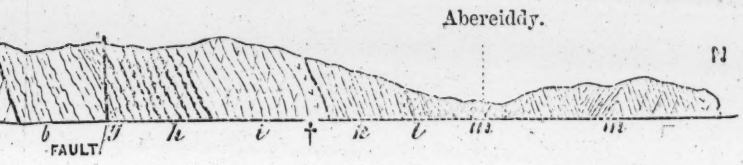
ZOIC ROCKS IN PEMBROKESHIRE, SOUTH WALES.

; Vertical Scale about 1 inch to 1000 feet.

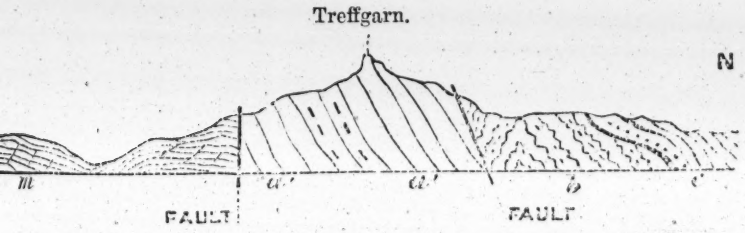
vid's Promontory, Pembrokeshire.



to the Coast N. of Llanrian, Pembrokeshire.



N. of the Treffgarn Rocks, Pembrokeshire.



b. Pebidian Formation
a'. Arvonian ,,
a. Dimetian ,,
† Igneous Rocks.

} Eozoic.

ON THE COLOURS OF SPRING FLOWERS.*

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EVERY one must have noticed the variations in the predominant colour of our wild flowers as the season advances from spring to summer and autumn. In our hedge-banks the pure white of the larger stitchwort and 'Jack-by-the-hedge' gives way to the bright blue of the speedwell, and then to the reddish-purple of the black horehound and the various shades of the mallows. In our meadows the golden-yellow buttercups are gradually replaced by the pink of the sorrels and ragged robins, and then by the yellow ragwort and purple knapweed. Our river-sides are gay in the early spring with the golden marsh-marigold, in the early summer with the yellow flag, in the later summer with the purple loosestrife. The bright scarlet of the poppies and the pimpernel only appears with the ripening corn. The blue campanulas, the bright-yellow St. John's wort, the purple heather, do not brighten the landscape till the summer is in its prime, when the green or inconspicuous flowers of the hazel, the elm, the oak, and nearly all our timber trees, have long since passed away. I do not know, however, that these facts have ever been tabulated, or any attempt made to reduce them to a general law; the present article is intended as a contribution to this object as far as our early spring flowers are concerned.

Under the title of early spring flowers I include all those

* An abstract of this Paper was read at the York Meeting of the British Association.

named in Hooker's *Student's Flora* as beginning to blossom not later than April, with a very few additions which I think ought also to be included, at all events in our southern counties, viz., *Ranunculus bulbosus*, *Lamium album*, and *Myosotis collina*. As my object is to ascertain the prevalent colour of the spring flora, I have confined the list to common plants, excluding those of less general distribution which might obviously introduce an element of error into the average. For this purpose I have taken as my guide the last edition of the *London Catalogue of British Plants*, and have struck out all which do not bear at least as high a number as 50. Though this mode of limitation is not altogether satisfactory—as plants of wide distribution may nevertheless not be common—it is, I think, the best available. In the limitation of species, I have followed Hooker's *Student's Flora*. The classification of colours, where so many shades are represented, is not easy. I finally decided on arranging them under five heads, viz., (1) white, (2) green, (3) yellow, (4) red and pink, (5) blue and violet. Very slight shades of colour, as in *Anemone nemorosa*, *Cardamine pratensis*, and *Oxalis acetosella*, are neglected. The sweet violet is placed under two heads. Finally, several large natural orders in which the flowers are very inconspicuous are entirely passed over, viz., the Amentiferæ, Juncaceæ, Gramineæ, Cyperaceæ, and Coniferæ.

The following is the classified list of common early spring flowers thus obtained :—

White.

Anemone nemorosa.
Ranunculus aquatilis.
Cardamine pratensis.
„ amara.
„ hirsuta.
Sisymbrium Alliaria.
Erophila verna.
Capsella bursa-pastoris.
Lepidium Smithii.
Teesdalia nudicaulis.
Viola odorata.
Cerastium semidecandrum.
„ glomeratum.
„ arvense.
„ triviale.
Stellaria media.
„ Holostea.
Oxalis acetosella.
Prunus communis.
Fragaria vesca.
Potentilla Fragariastrum.
Saxifraga tridactylites.
„ granulata.
Anthriscus sylvestris.
Bellis perennis.
Lamium album.

Green.

Ribes rubrum.
„ nigrum.
Callitriche verna.
Smyrnium Olusatrum.
Adoxa moschatellina.
Mercurialis perennis.
Ulmus montana.
„ campestris.
Arum maculatum.

Yellow.

Ranunculus auricomus.
„ acris.
„ bulbosus.
„ Ficaria.
Caltha palustris.
Ulex europæus.
Chrysosplenium alternifolium.
Tussilago Farfara.
Senecio vulgaris.
Taraxacum officinale.
Primula vulgaris.
„ veris.
Narcissus Pseudo-narcissus.

Red and Pink.

Sherardia arvensis.
Petasites vulgaris.
Vaccinium Myrtillus.
Lamium purpureum.
Orchis mascula.

Blue and Violet.

Viola palustris.
„ odorata.
„ hirta.
„ canina.
Vinca minor.
Myosotis collina.
Veronica agrestis.
„ Buxbaumii.
„ hederæfolia.
Nepeta Glechoma.
Scilla nutans.

Out of a total of sixty-four species, there are in this list 26 white, amounting to 40·5 per cent; 9 green, or 14·1 per cent; 13 yellow, or 20·3 per cent; 5 red or pink, or 7·8 per cent; and 11 blue or violet, or 17·4 per cent. I have not been able to prepare a similar list of our common summer and autumn flowers; but even without this there are a few points which strike one at once. Firstly, there is the very great preponderance of white flowers, which is certainly not the case at any other time of the year. Yellow is also greatly in excess as compared with other seasons; and the number of red and pink flowers is extremely small. It is obvious that if the excluded natural orders named above were restored, the plants belonging to them having mostly inconspicuous green or brown flowers, while some have bright yellow anthers, the proportion of red and blue in particular would be greatly diminished. It will be observed that the common cuckoo-pint is reckoned a green flower, from the colour of the spathe which encloses the whole inflorescence.

Before attempting to draw any conclusions from these figures, it may be useful to compare them with those relating to some other spring flora, say that of Switzerland. The difficulties in the way of any exact enumeration are here very great. The best materials at my hand are the two volumes already published of Seboth's *Alpine Plants;* but these include only 200 species selected for a special purpose. Although not entirely satisfactory, such a list may yield some trustworthy results. I have here taken May, instead of April, as the latest early spring month; and have no data from which to exclude any species on account of their rarity. From these volumes is compiled the following list of early spring-flowering Alpine plants:—

White.	*Green.*	*Yellow.*	*Red and Pink.*	*Blue and Violet.*
Anemone narcissiflora.	Convallaria verticillata.	Ranunculus Thora.	Anemone Halleri.	Thlaspi cepæfolium.
„ alpina.		Trollius europæus.	Thalictrum aquilegiæfolium.	Phyteuma comosum.
„ vernalis.		Draba aizoides.	Silene acaulis.	Myosotis alpestris.
Helleborus niger.		Biscutella lævigata.	Geranium macrorhizum.	Gentiana acaulis.
Arabis alpina.		Viola lutea.	Saxifraga oppositifolia.	„ verna.
Kernera saxatilis.		Orobus luteus.	Valeriana montana.	Pinguicula vulgaris.
Silene alpestris.		Geum montanum.	Erica carnea.	Soldanella alpina.
Mœhringia muscosa.		Aronicum Clusii.	Erinus alpinus.	Globularia cordifolia.
„ Ponæ.		Arnica montana.	Androsace chamæjasme.	
Saxifraga crustata.		Orchis sambucina.	Corthusa Matthioli.	
„ cuneifolia.			Primula villosa.	
„ petræa.			„ farinosa.	
Bellidiastrum Michelii.			„ commutata.	
Pinguicula alpina.				
Androsace chamæjasme.				
Daphne alpina.				
„ Blagayana.				
Narcissus poeticus.				

Out of fifty species in this list (one *Andrósace chamæjasme*, being again reckoned twice over among the whites and pinks), 18, or 36 per cent are white; 1, or 2 per cent green; 10, or 20 per cent red or pink; and 8, or 16 per cent blue or violet.

Several points of contrast between these two lists will at once suggest themselves. The very small number of green flowers in the second may no doubt be due partly to the fact that Seboth's work includes a selection only of Alpine flowers suitable for cultivation. But this will hardly account for the other differences; the smaller proportion of white flowers, and especially the very much larger proportion—about three and a half times as many—of red and pink flowers, a fact which will be in accordance with every one's recollection of the early spring flora of Switzerland. Now let us see whether we can arrive at any general conclusions from these data.

In the first place, it must be borne in mind that the two colours white and green stand on a different footing from all the rest, and may be regarded as, more correctly speaking, an indication of the absence of colour. The colour of green petals is not due to a mixture of blue and yellow pigments, but to the presence of chlorophyll, the ordinary green colouring matter of leaves. The bright colours of petals are not usually assumed till immediately before their emergence from the bud; and not a few—as for example those of *Cobœa scandens*, are still green when they first open, acquiring their proper colour only on full exposure to the light and warmth. A white flower again does not owe its colour to a milk-white fluid in the cells of the petals, but to the presence of air. Seeing, therefore, that the bright-coloured fluid pigments of petals are formed only under the influence of a sufficient supply of light and heat, the large proportion of green and white in our early spring flowers is easily accounted for. Then with regard to yellow, I find an exceedingly interesting observation by M. Flahaut* that 'a solid insoluble pigment, the *xanthine* of Frémy and Cloëz, is in the first place to be distinguished from all the soluble colouring matters, blue, yellow, red, and their mixtures, all of which are acted on very readily by reagents, and which are usually formed only in the epidermal cells.' This xanthine Frémy states to occur always in 'the form of clearly defined grains, occasionally in the epidermal, much more often in the deeper-lying cells, slowly soluble in alcohol and potassa. It is in all probability a modification of chlorophyll.' The following is a list of the plants in which he has detected it:—*Ranunculus, Primula, Cheiranthus, Galeobdolon luteum, Doronicum plantagineum, Alyssum saxatile, Cypripedium Calceolus, Azalea chinensis, Uvularia*

* *Bull. Soc. Bot. France*, xxvi. (1879), p. 249.

grandiflora, *Eranthis hyemalis*, *Forsythia viridissima*, *Tussilago Farfara*.

It is worth noting that these are without exception early, and some of them very early, spring-flowering plants. The colours, therefore, which pre-eminently distinguish our summer and autumn flora, the reds, pinks, blues, and some yellows (not due to xanthine, but to a soluble yellow pigment), are caused by the presence of substances which require both a strong light and a high temperature for their production, and Professor Batalin has shown this to be especially the case with the red colouring substance.* That the same species of flower frequently assumes a more intense colour with increasing altitude in the Alps is a matter of ordinary notice, confirmed by the exact observations of M. Bonnier,† who states that this change is due to an actual increase in the amount of colouring matter in the cells. The difference already pointed out between the prevailing colours of the spring flora in England and in Switzerland, seems to me to be due to the same cause. Owing partly to the spring being a month later, partly to the more southern latitude, and consequent greater elevation of the sun, partly to the clearer air of a high altitude, the light which opens the earliest spring flowers is much stronger in Switzerland than in England, causing the appearance of those brilliant roses and pinks of the Silenes, Ericas, and Primulas, and blues of the Gentianas, Soldanellas, and Phyteumas, with which we have, with the exception of our blue-bells, scarcely anything to compare in our spring flora. In the list given above, the most striking feature of the early spring flora of Switzerland is seen to be the very large ingredient of red and pink: but I believe a more complete analysis would show an almost equal preponderance of blue.

I have not in this paper touched on the interesting subject of the adaptation of the various colours of flowers to fertilization by insect agency, about which much has been, and very much might be, written. As Hermann Müller points out in his most recent publication,‡ changes in the colour or form of flowers which are serviceable to them for purposes of fertilization, can only be the result of external physical causes, and must be perpetuated by natural selection acting on heredity. This writer, who has made the subject specially his own, fully confirms the statement of the greater brightness of colour of the flora of the Alps as compared with that of the plains, a result not only of the occurrence of brighter-flowered species,

* *Acta hort. Petrop.* VI. ii. p. 279.

† *Bull. Soc. Bot. France*, xxvii. (1880), p. 103.

‡ *Alpenblumen; ihre Befruchtung durch Insekten und ihre Anpassungen an dieselben. Leipzig*, 1881.

but also of the greater intensity of colour in the same species. This he attributes to the greater transparency of the mountain air, and consequent more intense light, an explanation which is confirmed by the experiments of Siemens with the electric light.* The observations of Müller with regard to the prevalent colours of Alpine flowers are completely in accord with those stated above, viz., the comparative scarcity of white, and the remarkable prevalence of red and blue flowers; he further states that those flowers only are red or blue which are visited chiefly or exclusively by bees and 'hover-flies' (Syrphidæ). It would be interesting to compare this fact with the time of year at which these groups of insects are most abundant.

The conclusions arrived at in this paper are somewhat at variance with those of Mr. Buchan,† who states that the blues, on the average, flower considerably the earliest; then, in order, the whites, purples, and, lastly, the yellows and reds. It is possible that the discrepancy may arise from Mr. Buchan having based his result on the entire English flora, while I have taken only the commonest flowers.

* See *Nature*, 1880, vol. xxi. No. 535.

† *Proceedings of Edinburgh Botanical Society*, 1876.

ON THE RETREAT OF THE EUROPEAN GLACIERS.

By Professor C. DUFOUR.*

IN 1870, when M. F. A. Forel and myself were on the Rhone glacier, we mapped the front of the glacier. I have since repeatedly communicated to the Society the results of fresh measurements which have been made there, and which, year by year, have shown that this glacier was undergoing a considerable diminution, so that, in 1879, it had gone beyond all previous limits, so far as the memory of the inhabitants of the country could go back. This retreat, which commenced about 1855 or 1856, is not peculiar to the Rhone glacier; it is a general phenomenon throughout the chain of the Alps, although it did not commence everywhere at the same time, some glaciers were advancing when others were decreasing. But at present it may be said that the retrograde movement has become the rule in all the Alpine regions.

In 1878, at the Scientific Congress in Paris, I had the opportunity of conversing on this subject with several French *savants*, and learned from them that the glaciers of the Pyrenees were in the same case; all of them had diminished, and some had actually disappeared. It then became an interesting point to ascertain whether the other European glaciers, those of the Caucasus and of Scandinavia, presented the same phenomenon. With this purpose in view, I applied, with regard to the former, to M. Wild, the director of the Central Physical Observatory of Russia, and with regard to the latter, to a Swede, M. Nyström. These two gentlemen were kind enough to obtain the information that I asked for, and from their investigations it appeared that these groups of glaciers had diminished in the same way as those of the Alps and Pyrenees. In the Caucasus the retreat commenced, as in the

* From the *Bulletin de la Société Vaudoise des Sciences Naturelles*, Series 2, vol. xvii. pp. 422–425.

case of the Rhone glacier, in 1855 or 1856. In Scandinavia, it appeared to have varied from one glacier to another, but it has now become general. M. Nyström was so kind as to consult the illustrious Swedish traveller, M. Nordenskiöld, upon this subject, who told him that the glaciers of Spitzbergen had undergone a similar diminution during the last few years.

In August, 1880, I laid a communication on this subject before the Scientific Congress at Rheims. In the discussion which arose upon the matter, several people cited facts in support of those which I had pointed out; and one of those who took part in the debate, and who had been several times to Greenland, had observed that the glaciers of that country had also retreated considerably.

It would be interesting to know what has been the condition of the Asiatic and American glaciers, and of those of the southern hemisphere, during the same periods. But in any case the retreat of the four great European groups of glaciers, those of the Pyrenees, the Alps, the Caucasus, and Scandinavia, as well as those of Greenland and Spitzbergen, is a fact of great importance in physical geography, since it involves all those of the northern hemisphere over an extent of 100° of longitude. It is well worth while to pay attention to it, and to watch the progress of the phenomenon.

It is perhaps difficult at the moment to indicate the cause of this retreat, for, from the meteorological point of view, the last few years have not been very different from those which preceded them. Moreover, the advance or the retreat of a glacier depends upon several factors; first of all, upon the heat and humidity of the summer, and then upon the frequency and intensity of warm winds. As regards heat and wind, the consequences are indirect, but they are less so with respect to humidity. In fact, as M. Forel and I have shown by experiments made in 1870 upon the Rhone glacier, the aqueous vapour of the atmosphere condenses upon the ice, as it condenses in winter upon the glass windows of our rooms, and this water of condensation considerably augments the volume of the water that issues from the glacier; now this condensation is accompanied by an evolution of latent heat, which contributes greatly to the melting of the ice. But the extent of a glacier depends not only upon the forces which tend to destroy it, but also upon those which tend to form it, that is to say, upon the accumulation of snow in the basin of reception which is the origin of the glacier. These snows, which by degrees become converted into ice, are in considerable quantities, and represent the falls which have taken place during several years. This mass moves slowly, and it is not until the lapse of a great many years that the ice,

thus formed, arrives at the bottom of the glacier, where it melts. All this ice, therefore, represents the sum of the meteorological actions that have taken place during a very long period of time, perhaps more than a century.

It would, therefore, be a mistake to seek in the last few years alone the cause of that retreat of the glaciers which we can now demonstrate. This would, no doubt, be the right course if the retreat were caused solely by a more rapid melting, but it is quite otherwise if this cause ascends to the very origin of the glacier. Now the latter is probably the case, for meteorological observations do not reveal to us any notable difference between the last quarter of a century and a preceding period. This is why the investigation of the great retreat of the glaciers that we now witness, must not be neglected; it is right to watch and trace it to the end in all those countries where it has been demonstrated; and the cause of this retreat, if we succeed in ascertaining it, will be an important factor among those which engage our attention in the study of the physics of the globe.

Now, with regard to most glaciers, it is not difficult to appreciate the amount of the retreat. It is only necessary to draw a map of the lower extremity, as I have done several times with M. Forel in the case of the Rhone glacier; and in a question of this kind, with an element so variable as a glacier, it is not necessary to determine the position of each point within a centimetre or two. Upon the moraine in front of the glacier we have established two fixed points, by means of two stakes firmly driven into the ground down to the level of its surface; thence, with a small sextant, we determine the position of the most important points of the front of the glacier, which enables us to map it, and to see readily for each region of the glacier the amount of the retreat from year to year.

THE STORAGE OF ELECTRICITY.

By J. MUNRO, C.E.

THE last five years have been marked by an extraordinary development of electrical invention. They have given us the speaking telephone and the microphone, which may now be found working conjointly in transmitting all varieties of human speech by wire in every clime, from London to Honolulu, and from Stockholm to Melbourne. They have given us the duplex and quadruplex modes of sending an ordinary telegram, so that two, and even four messages of entirely different import may be passed through a single overland line or submarine cable simultaneously, without either jostling or obliterating one another. They have given us the electric light to illuminate our streets, factories, and homes with artificial sunshine; and they have given us the means of conveying power by electricity to great distances, so that in the future we may drive our looms and speed our trains by the energy of waterfalls among the hills, and light our beacons by the fury of the waves which break around them. A thousand possibilities of electric labour open on our sight, and in a few minutes we can prophesy what the next fifty years will fulfil.

The application of electricity to lighting and motive purposes which promises so largely for the future, is chiefly due to the recent perfection of the dynamo-electric machine, whereby electricity is generated in a coil of wire rapidly rotated in the magnetic space between the opposed poles of two powerful electromagnets. Unlike the clumsy and troublesome voltaic battery, it is compact and portable, and yields a steady current so long as the coil is rotated. This current may be conducted by wires to an electric lamp, and there transformed into a splendid light; it may be used instead of a battery-current to transmit telegrams, after the fashion of the great Western Union Telegraph Company of America; or it may be sent through a second

dynamo-electric machine so as to set its coil rotating by a reversal of the generating process, and thus perform work like any other engine. Electricity, then, can be produced in large quantities, and conveyed to long distances with the speed of light; but there remains another property which it would be well to have, if ever it is to become of universal service. It should be capable of being stored up, like water in a tank or coal-gas in a holder.

Hitherto electricians have not been quite devoid of apparatus for storing electricity. They had the contrivance known as a 'condenser,' in which two or more sheets of tinfoil, A, B, are separated by an insulating material, C, such as paper soaked in wax-paraffin, or mica. When A is connected to one pole of a voltaic battery and B to the other by the wires WW, the metal plates take in a charge of electricity, after the manner of the Leyden Jar, and will contain it for an indefinite time. To discharge them it is only necessary to connect A to B by a conductor; but this discharge is instantaneous, and therefore quite unsuited for electric lighting, or motive purposes, where a steady and continuous *current* is required. Besides the 'condenser,' there is however another contrivance known as the 'secondary battery,' which takes in its charge by degrees and gives it out again just as gradually; and under the exigencies of modern life, this apparatus has been so far improved within the last few months as to become a practical reservoir for electricity.

The 'secondary battery,' as it is called, originated, first of all, in a discovery made by a French *savant* named Gautherot as far back as 1801, or about a year after Volta's pile, the progenitor of the present voltaic battery, appeared. Gautherot connected wires of gold to the poles of the Volta pile, and when he plunged them in water to decompose it into its constituent gases, oxygen and hydrogen, he noticed that these wires themselves yielded a brief current after the pile itself had been disconnected, and always in a direction opposite to the current of the pile. This effect, which is familiar to students of electricity under the name 'polarization of electrodes,' was remarked still later by a German physicist, Ritter, who fertilized the observation by his genius and thus created the first 'secondary battery.' Ritter devised several batteries for the express purpose of supplying these secondary currents; he tried plates of platinum, silver, and iron in place of the gold wires of Gautherot, and immersed them in solutions of different salts instead of water; but he was wrong in supposing the return current to be due to electricity which had soaked into the plates or intervening fluid. The true explanation was given by Volta, Marianini, and afterwards by Becquerel, who showed that the

reaction arose from the oxygen and hydrogen of the decomposed water collecting on the metal plates and changing their electric condition with respect to one another; making them, in short, like the two different metals of a voltaic cell instead of one and the same substance. This explanation was further verified by Grove, who, in 1843, actually constructed a 'gas battery,' in which the positive and negative plates or poles of the combination were both composed of sheet-platinum, but one was surrounded with oxygen gas and the other with hydrogen. On connecting these platinum plates by wire, a current was obtained from them, as in the ordinary voltaic cell.

The liberation of gases which goes on in the secondary battery is well shown in the action of the voltameter, Fig. 1. Here the current from a voltaic battery with zinc and copper plates, Z and C, is passed through a little acidulated water contained in

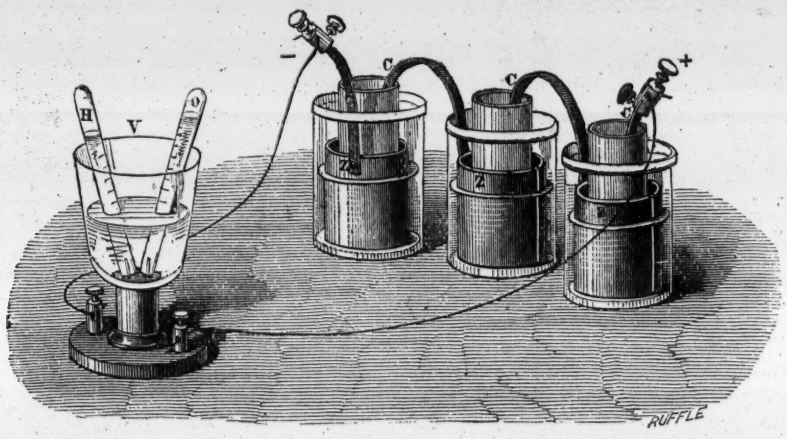

Fig. 1.

the vessel V, and the dis-parted gases, hydrogen and oxygen, are collected in the inverted tubes, H and O, the hydrogen appearing over the wire connected to the zinc or negative pole of the battery, and the oxygen over the copper or positive pole. In the secondary battery these gases collect on the metal plates which are connected to the poles of the charging battery; and when the latter is removed, the secondary current begins to flow, provided always the circuit is completed by joining the plate with a wire. The charging current flows through the liquid from the copper or positive pole to the zinc or negative pole; but the discharging current flows in the contrary direction, that is to say, from the plate on which hydrogen was deposited to the plate on which oxygen was deposited. Speaking generally, the secondary current flows through the liquid from the plate which was connected to the negative pole of the

charging battery or machine to the plate which was connected to the positive pole; and it continues until the separated gases have all recombined to form water.

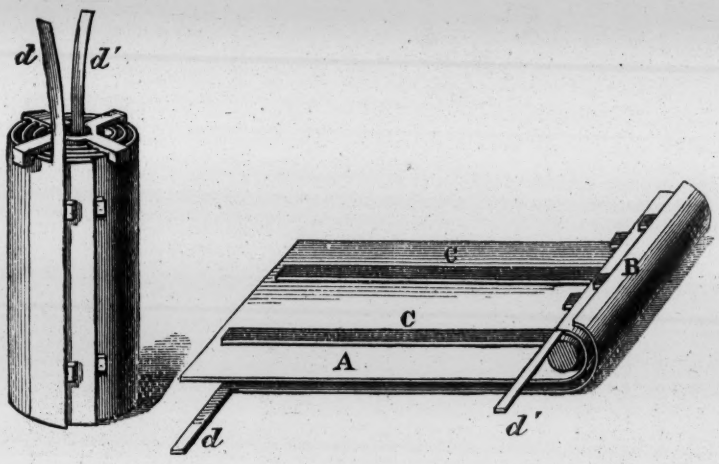

Fig. 2.

In 1859, a great improvement on the secondary battery was made by M. Gaston Planté, of Paris, who, after trying many different metals, selected plates of lead in preference to any other. Lead had been tried by Ritter and abandoned; but in

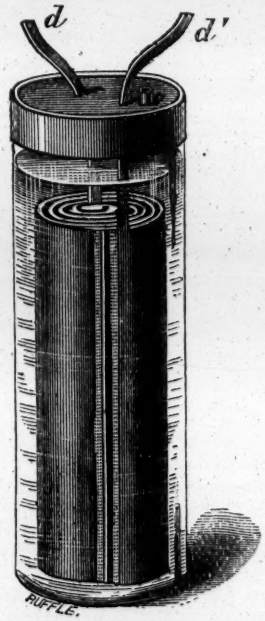

Fig. 3.

the hands of Planté, and latterly of Faure, it has afforded a practical solution of the problem. Planté takes two sheets of lead, A B, Fig. 2, with projections, *d d'*, jutting from them, and

after separating them by two strips of thick felt, C C, he rolls them up together and plunges them into a vessel of water acidulated with sulphuric acid. As shown in Fig. 3, this arrangement constitutes a single cell of the Planté battery, the 'electrodes' of which, *d d'*, are brought up through the cover. The large surface of the plates increases the capacity of the cell, and their close proximity to each other diminishes its internal resistance. These cells can be readily charged by a dynamo-electric machine, after the manner sketched in Fig. 4, where the ends of the rotating coil are seen to be connected to the lead plates. Thus charged they will give back the current from the machine any reasonable length of time afterwards with very little loss, and always the discharging current flows *out* of the electrode by which it formerly flowed *in* as a charging current.

Age improves their capacity, for the repeated charging forms a thick film of brown peroxide of lead on the surface of

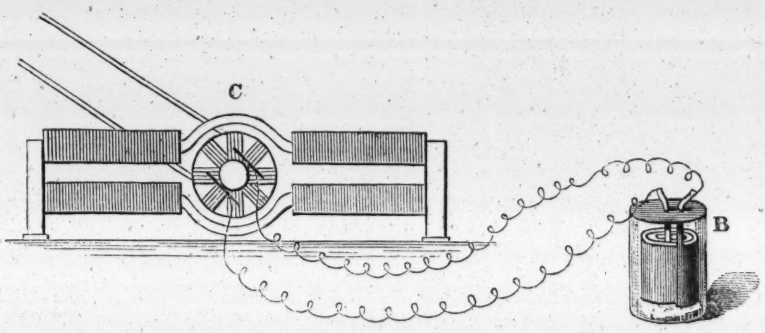

FIG. 4.

the plate at which the oxygen collects, and the other plate acquires a spongy texture owing to the gases liberated there. During the discharging of the cell, the plate which was peroxidized in charging, becomes again deoxidized, and the current flows until this process is complete.

Planté's battery has long been used by surgeons as a portable store of electricity for supplying the current necessary to white-heat the fine platinum wire with which they perform the actual cautery. A single cell charged by a pair of Bunsen cells before the surgeon starts on his rounds is sufficient for this purpose. It has also been used to feed a small electric lamp by means of a considerable number of cells coupled together on a portable frame.

Within the last few weeks, however, a further improvement has been made on Planté's secondary battery by M. Camille Faure, who has obviated the waste of time necessary to produce the film of peroxide on the Planté plates by surrounding each

lead plate in the first place with a layer of red lead, or minium, made into a paste with water, and enclosing it in a sheath of felt. The two lead plates are then laid one over the other, as in Fig. 5, and rolled together, then placed in the lead vessel represented in Fig. 6. Thus constructed, the minium of one plate is itself oxidized by the charging current and the preliminary formation of peroxide from the lead which took place

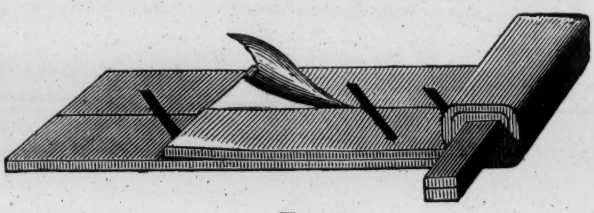

FIG. 5.

in Planté's original form is avoided, whilst the capacity of the Faure arrangement for electricity is considerably greater than that of Planté. How much greater, it is difficult to determine at this early date. One electrician claims a forty-fold increase of capacity, weight for weight, and another puts down the increase at only 20 per cent. It is tolerably certain, however, that a Faure battery weighing 165 lbs. is capable of storing a quantity of electric energy equivalent to one-horse power of work ex-

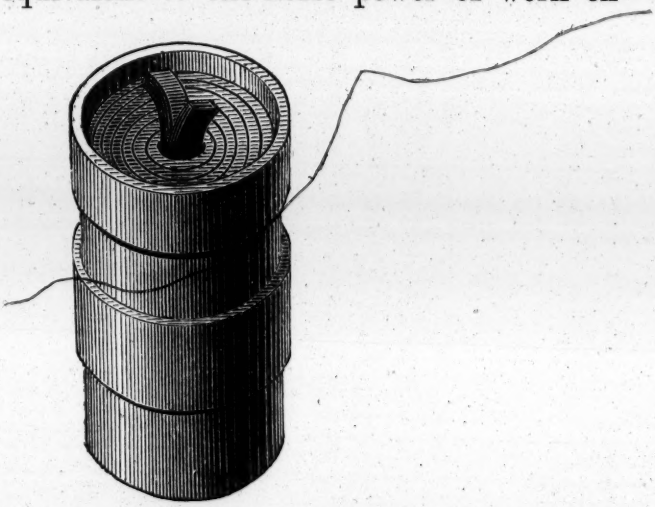

FIG. 6.

pended for an hour. Such a battery was recently sent from Paris to Sir William Thomson, at Glasgow; and that distinguished physicist has published his opinion that an accumulator weighing fifteen hundredweight will suffice to operate for six hours from one charge, doing work at the uniform rate of one-horse power and with a loss of only 10 per cent of the original charge through leakage and so on.

Experiment alone can demonstrate the practical value of the Faure accumulator; but Sir William Thomson thinks that it will not be too heavy to place on board a tram-car or an omnibus, in order to drive the vehicle by its charge in preference to horses. This would be effected by reversing the arrangement shown in Fig. 4, and causing the discharge of the battery, B, to rotate the coil, C; the motion thus produced being, of course, communicated to the wheels of the carriage. In the Siemens electric railway in Berlin, the electricity is conveyed by a wire along the track from a stationary generator at one terminus of the line to the coil of a dynamo-electric machine attached to the locomotive; but there are cases of locomotion in which this plan cannot be followed. Omnibuses, for instance, require to be independent of such a wire, so do boats, balloons, and tricycles. The electricity required to turn the wheels of such free and independent vehicles must therefore be carried with them, either in a voltaic battery, from which it can be got at first hand, or in a secondary battery, giving it at second hand. But in point of lightness and convenience, the secondary battery is far superior to the other, so that we may expect it to be preferred. Recent experiments, by M. Trouvé of Paris, have shown that boats, launches, and velocipedes, may be successfully driven by the electric current; and the prospect is all the better now that M. Faure's secondary battery has come out.

In surgery it has already proved its usefulness in the hands of Prof. George Buchanan, of Glasgow, who excised a nævoid tumour from the fore-tongue of a lad, without losing a drop of blood, through the agency of a wire heated to redness by the current stored in a Faure battery, 9 inches high by 5 inches in diameter. It is in electric lighting, however, that the Faure, or at any rate some other secondary battery, will be most valuable. According to Sir William Thomson, a battery of seven cells, of the above size, is sufficient to keep four or five of the electric lamps of Mr. Swan glowing for at least six hours, with a total luminous effect of 100 candles! It follows that with several of such batteries stationed in a house, and charged with electricity during the day by means of wires from the works where the current is generated, it will be possible to light up the rooms by night, and perform such light operations as turning a coffee-mill or a sewing-machine. The same battery will drive a sewing-machine several hours a-day for a week. In fact, it is not going too far to say that an electric reservoir will be as much a part and parcel of the home in future as a water-cistern or a coal-bin is to-day.

ON THE FORMATION OF THE TAILS OF COMETS.

By M. FAYE.*

IN the *Comptes Rendus* of June 27, I read, not without surprise, a note by M. Flammarion, in which the learned author throws doubt upon the materiality of the tails of comets, and the existence of the repulsive force which produces them, a force the principal characters of which were formerly indicated by me.

It is curious that these denials appear in the same number of the *Comptes Rendus* as the spectroscopic observations of MM. Huggins, Wolf, and Thollon, which show in the analysis of the light of the present comet the super-position of two spectra, evidently due to the presence of material molecules, some reflecting the light of the sun, the others also emitting a light of their own. Moreover, this is what spectrum analysis has proved for all comets, without exception.

The argument upon which M. Flammarion depends recurs to the idea that the comet carries its tail as a sort of brush continuous with itself. He concludes that the extremity of this brush must sweep through space with the frightful velocity of 16,000 leagues per second; and in consequence the above-mentioned brush is not a body, but an appearance, a sort of luminous phantom due to the excitation of the ether situated behind the comet.

This is due to a misunderstanding of one of the greatest scientific problems of our epoch. There is not an astronomer who believes that the tail of a comet is a rigid whole attached to the nucleus: one might as well imagine that the smoke of a steam-boat that started from Havre, and that one sees arriving at New York, has crossed the Atlantic with the vessel. It is two centuries since Newton explained these matters by showing that each section of the tail taken at a given moment was

* Read before the Academy of Sciences of Paris, July 11, 1881.

abandoned by the head at an antecedent period—a period more distant in proportion as the section itself is further removed from the nucleus. Each of these sections has followed, in space, an orbit absolutely different from that of the head of the comet; and the tail, in its entirety, is nothing but the envelope of the positions occupied at a given moment by the series of puffs of cometary matter successively emitted and driven off on the preceding days, without there being between them any other connexion than the velocity of translation which they possessed in common at their points of departure.

Calculation applies perfectly to these singular but by no means mysterious phenomena. Bessel furnished their formula, which enables us to determine by the curvature of the tail the intensity of the force that produced it. Quite recently, M. Bredichin, director of the Observatory at Moscow, has obtained from it most interesting results.

As to this force which M. Flammarion denies, although in every comet we see its effects marked in the heavens in gigantic features, it is certain that matters go on as if the Sun was endowed with two actions—one attractive, belonging to its mass, the other repulsive, due to its electric (Olbers), magneti-polar (Bessel), or calorific (Faye) state. We may dispute its essence, or its physical nature, but not its mechanical characters, as I have defined them, because these characters result from the observed facts, namely,—

1. This repulsive force is not proportionate to the masses, like attraction, but to the surfaces. Hence it produces the more marked effects in proportion as the matters subjected to it are less dense.

2. This force is not exerted through all matter, like attraction; it is on the contrary weakened, or even arrested by the interposition of the smallest screen.

3. It is not propagated instantaneously, like attraction, but gradually, like light and heat. It results from this that its action upon a point in motion is not exerted in the same direction as attraction, even though the two forces emanate from the same body.

4. Lastly, this force varies inversely to the square of the distance, like the intensity of light and heat. This is the sole point of resemblance between the two forces which the Sun exerts simultaneously upon all bodies, one which is connected with its mass, and therefore invariable, the other with its physical condition and consequently transitory.

This latter force necessarily affects the planets and their satellites as well as the comets. The first of the four characters that I have just indicated will explain how its action upon the planets, which are of incomparably greater density, has hitherto

escaped the notice of astronomers. It is a problem reserved for a comparatively near future.

It is exerted also upon our planet at the boundaries of our atmosphere, but its meteorological effects are masked by those of solar radiation, which is much more powerful, and the period of which is exactly the same. I have at least endeavoured to demonstrate its presence around us by the action of incandescent laminæ upon very rarified matter, which I rendered visible by means of electrical currents. In this great difficulties are met with, which will not surprise any one who considers the trouble it has taken to compel even attraction to manifest itself about us between neighbouring bodies.

* * * * *

In conclusion, I would indicate that the simultaneous existence of several tails, with very different curvatures, is one of the most striking verifications of the characters above assigned to the repulsive force. These multiple tails are not exceptional as was formerly supposed; their presence is a fact which tends to become generalized as comets are observed with very powerful instruments. It is true that the present comet seems to have only one, but this is no doubt due to our being at no great distance from the plane of the orbit, the plane in which all the tails are formed, so that, so far as we are concerned, they are projected one upon the other. It is for the same reason that the tail of the present comet is apparently straight. If instead of seeing it edgewise we saw in face, its natural curvature would strike all eyes.

ATYOIDA POTIMIRIM, A MUD-EATING FRESH-WATER PRAWN.

By Dr. FRITZ MÜLLER.*

THE cleaning of the branchial cavities is performed in some Prawns, such as *Palæmon*, by the first pair of thoracic feet; in the Hermit Crabs, *Porcellunæ*, &c., by the last pair of those feet; and in the true Crabs, by the flagella of the three pairs of jaw-feet. This function is performed in another and quite different manner in a small Prawn found in the river Itajahy, *Atyoida Potimirim*. This little Prawn further presents so many remarkable peculiarities, that some account of it may not be uninteresting even to those readers who do not know much about Crustacea.

The first thing that strikes one is the structure of the hands (claws) or *chelæ*, with which, as in the great majority of the Prawns, the first two pairs of thoracic limbs are armed. The claws, or hands, of Crabs and Lobsters are produced from ordinary walking limbs, by the development of a process of the last joint but one beyond the articulation of the last joint, the last joint and this process being then opposed to each other. We thus have to distinguish the movable finger, the immovable thumb (the process), and the true hand; the latter, as every one knows who has eaten a crab or a lobster, forming the main mass of the claw, and enclosing the powerful muscles which move the finger.

In our *Atyoida*, however, we can hardly speak of a true hand in contradistinction to the thumb; the chela is cleft through its whole length, and the joints of the hand and finger are at the same level. To add to the extraordinary aspect of the claw, the hand is very freely articulated to the lower angle of the deeply-notched fore-arm, and the apical third of each of its divisions is furnished with a dense coating

* *Kosmos*, Band ix. p. 117.

of remarkably long bristles. When the hand is closed, all these bristles meet together to form a long, pointed pencil. They are always seen thus in dead animals, and the hands thus appear quite unfitted for seizing anything, and give no room to suspect what an attractive spectacle they present in the living animal, and how beautifully they are adapted to the food of the animal. This consists of mud, especially the fine mud which settles on aquatic plants and is rich in all sorts of minute living creatures, as well as in decomposing animal and vegetable matters. When the hand opens, the bristles forming the pencil spread out in the same plane, arrange themselves almost perpendicularly to the margins of the fingers, and thus constitute two broad fans, which can take between them a quantity of fine mud particles swept off the leaves of plants; as the hand closes, the bristles also close together again from all sides, and thus press together the food collected into a small morsel, which is conveyed, or rather flung, into the mouth, all the movements being so rapid as scarcely to be followed by the eye. Scarcely is one morsel swallowed, when there comes a second and then a third hand with a new cargo. When the animals are feeding upon the soft mud of the bottom, where they have only to lay about them briskly, the four hands whirl about one over the other with the most restless rapidity. The inner bristles of the fingers are considerably shorter and stiffer than the outer ones; the latter are simple, the former pectinated; they enable the fingers to strip off the adherent slime from delicate roots and stems, which they take between them. It is also very pretty to see the animal lying in wait, if I may use the expression, to seize the fine particles of food floating in the water, whirled towards it by the outer branches of the middle and posterior jaw-feet. The chelæ, opened about at a right angle, hang down from the fore-arm, and all four of them form a transverse series, the second pair of feet, although articulated further back, being longer than the first pair; and from the great breadth that each separate hand acquires from its long bristles being spread out laterally, they keep watch over a very considerable space. From time to time we see one or the other of the chelæ close up and move towards the mouth.

The structure of the organs of the mouth, like that of the hands, is connected with this mode of nutrition, and differs in many respects from that occurring in the Palæmonidæ and other Prawns, as indeed in the other Decapoda generally. The hinder maxillæ, the anterior jaw-feet, and in a less degree also the middle jaw-feet, have a remarkably long, straight inner margin, densely clothed with stiff bristles, some of which are of very peculiar form. It will be easily understood how

useful these great folding-doors, with their dense armature of bristles, must be in the reception of morsels made up of fine, loose particles, merely pressed together.

The mandibles, also, are very remarkable. Quite recently it has been put forward, as a distinctive character between the Long-tailed Decapods and the Mysidæ, that 'the right and left mandibles are similar in the Macrura, dissimilar, and often very different, in the Mysidæ.' Even leaving *Atyoida* out of the question, this supposed distinction will not hold good (in the Palæmonidæ, for example, the tubercles of the masticatory processes are quite different to the right and left); but nowhere else among the Macrura have I seen so great a difference between the two mandibles as in our *Atyoida*, where it strikes one at the first glance. I would regard this as an old inherited character rather than as a recent adaptation, more especially seeing that in other respects, also, the mandibles show an ancient form. In those Prawns which have retained to the present day the most complete and original developmental history, the mandibles, at their first appearance in the interior of the third pair of limbs of the Nauplius, show an apical part armed with cutting teeth, a manducatory process furnished with transverse ridges behind this, and between the two a series of bristles; and we find the same three parts in *Atyoida*. Such mandibles are nowadays rare among the Decapoda, but frequent in others of the higher Crustacea, such as the Amphipoda and Cumacea.

The two pairs of feet which follow the chelæ (the third and fourth thoracic limbs) are slender walking limbs, the last joint of which is armed with from six to nine curved, claw-like spines, such as are also met with in other Prawns (*e.g. Hippolyte*), which, like our species, are fond of clinging to plants. The last or fifth pair of limbs is also employed in walking and clinging, and has a few curved spines at the end of the finger; but in addition to these, the lower edge of the finger bears a delicate comb, employed especially in cleansing the abdomen. A systematic cleansing of the abdomen is performed by the animal with great care and deliberation, and occupies several minutes. It commences with the first pair of swimming feet, the four following ones being for the time laid back; when the first pair and the space between the first and second is clean, the second pair comes up, then the third, and so on. Last of all, it comes to the turn of the tail, which has to bend very much forward in order to come within reach of the comb.

Neither the two anterior pairs of limbs, the hands belonging to which, with their long bristles, may occasionally be seen sweeping about the fore part of the body, nor those of the last pair, are adapted to penetrate into the branchial cavities and

cleanse them. This is effected by the posterior maxillæ. It is well known that in all Decapoda these maxillæ have externally a large broad plate, which is placed as a valve at the outlet of the branchial cavity, and by its movements maintains the respiratory current; in this we distinguish more or less distinctly an anterior part and a posterior section, of which the former must be interpreted as the outer branch, and the latter as the flagellum. When the plate serves only as a valve for regulating the respiratory current, this hinder section is short and truncated, or rounded off at the end, and scarcely extends into the branchial cavity itself; in *Palæmon*, for example, it reaches only to the gill of the outer jaw-foot. In *Atyoida*, on the contrary, this hinder portion is long and narrow, tapering towards the extremity, and here furnished with about a dozen very long flexible bristles; it reaches as far as the last gill but two, which is seated upon the third pair of feet, and its apical bristles to the posterior extremity of the branchial cavity. Thus, as may easily be ascertained by the examination of sufficiently transparent living animals, the whole outer surface of the branchiæ may be swept by it.

Another arrangement may assist in keeping the branchial cavity clear, and this occurs also in many other prawns, such as the very large genus *Hippolyte*. The posterior jaw feet and a variable number of the thoracic feet (in *Atyoida Potimirim* the first three pairs) bear a minute flagellar appendage, which, from its small size, might be regarded as stunted if its peculiar structure did not contradict any such notion. In our *Atyoida*, it may be described as a small sausage-like appendage which originates near the anterior margin of the coxa, and, being directed backward, is applied by its inner surface to the outer surface of the coxa. Its outer surface is beset with about a dozen rather long, straight hairs, arranged in two rows, and its free extremity is furnished with a hook, which probably serves to keep it in position. These flagellar appendages then lie in the entrance to the branchial cavity, in the fissure between the coxæ of the feet and the lower margin of the carapace; they narrow this entrance, and thus, as also by their armature of hairs prevent the entrance of foreign bodies.

But, it will be objected, they are deficient precisely where they would be most necessary, namely, where the water flows most rapidly into the branchial cavity, above the fourth and fifth pairs of feet. Here, however, there is another very peculiar arrangement for the same purpose, and one that, so far as I know, has been observed in no other prawn. The abdominal feet of the prawns, as is well known, are (with few exceptions) of two branches; the branches usually have the form of tongue-shaped leaves, the margins of which are fringed with long,

plumose swimming-bristles. In repose, these swimming feet are thrown forward and laid between the thoracic limbs. Unlike all other prawns that I have seen, in *Atyoida* the outer branch of the first pair of swimming feet is not laid between the last feet of the thorax, but outside over them and the entrance to the branchial cavity, so that all the water entering here is strained through its plumose hairs.*

The males of our *Atyoida* are much smaller than the females; I never found the former more than 15 millimetres, while the latter were as much as 25 millimetres long. The better the males are equipped with offensive and defensive weapons, and the more violently they struggle for the possession of their females, the more do they usually exceed the latter in size. This is the case among the prawns of the Itajahy with the male of *Palæmon jamaicensis*, whose chelæ of more than a foot in length almost always bear traces of the battles which it has fought with its rivals. Where weapons are wanting, the female often attains a larger size, which is probably superinduced by the much greater expenditure of material called for by the eggs. To give a second example belonging to the series of the higher Crustacea, I will refer to the Tatuira (*Hippa emerita*), the males of which likewise appear quite dwarfed by the side of the females. Just as in *Atyoida* the males have become or remained unarmed by the adaptation of the chelæ to the purposes of mud-eating, in the *Hippa*, which burrows in the sand, this has come about by the conversion of the apical joints of the legs into broad shovels, only available for digging.

The hands of the male *Atyoidæ* seem to be unfitted not only for contests with their rivals, but also for seizing and holding the females, and it is therefore not surprising that other arrangements have been developed in them, such as we do not find in other prawns whose hands are sufficiently capable of grasping. Thus the terminal spine of the posterior jaw-feet, which is straight in the female, is converted in the male into a curved claw; and on the inner surface of the tibiæ of the third and fourth pairs of feet there is a strong denticulated spine, and opposite to it numerous wartlike tubercles, which, like the spine, are entirely wanting in the female.

There is yet another remarkable difference between the sexes to which I must refer. In the males, the inferior angle of the anterior margin of the carapace is rounded, while in the females it is produced into an acute tooth (Simpson's 'spina pterygostomiana'). Exceptions to this rule are very rare. The armature of the anterior margin of the carapace has hitherto

* From Milne-Edwards' figure of *Caridina typus* (*Hist. Nat. Crusst.* Pl. xxv. *bis*, fig. 4), I conclude that in this respect the nearly allied genus *Caridina* agrees with *Atyoida*.

not only served as a certain character for species, but it has even been employed for the distinction of genera. Thus, the genus *Leander* has been separated from *Palæmon* solely because the former possesses a 'spina branchiostegiana,' but no 'spina hepatica;' and the latter a 'spina hepatica,' but no 'spina branchiostegiana.' Now, in *Atyoida Potimirim* the presence or absence of the 'spina pterygostomiana' constitutes a simple distinction of sex or age, for all the younger females of less than 12 millimetres long agree with the males in wanting the spine at the lower angle of the carapace. As the males remain much smaller than the females, it seems quite intelligible that many peculiarities of the females, which only make their appearance when the latter have grown to exceed the size of the males, may never arrive at development in the latter. In this way, for example, we may explain the difference in the number of bristles at the extremity of the last segment of the body, or the middle caudal plate (*Telson*) in adult males and females, as this number in general increases with size and age, although it is not always the case that larger animals have more numerous bristles. In eleven young animals, 8–12 millimetres long, which as yet showed no external sexual differences, I found from 6 to 9, or an average of 7·1 bristles; ten males of 12–13 millimetres had 8–10, or an average of 8·7 bristles; in eleven males of 14–15 millimetres, the number of bristles varied between 8 and 10, but the average amounted to 9·9; in nine females of 12–19 millimetres there were 8–14, average 10·6 bristles; and lastly, in fourteen females of 20–24 millimetres, from 12 to 17, or an average of 14·4 bristles, were present.*

It would be equally easy to correlate the absence of the tooth at the lower angle of the carapace in the males with their smaller size, if it were not that in females of 13–15 millimetres in length, which consequently do not yet exceed the adult males in size, the tooth is already at all events indicated, and in general even developed to its full size. Under these circumstances the most probable supposition seems to me to be that the 'spina pterygostomiana' first appeared in adult, or nearly adult, females, and in course of time was produced in younger and younger individuals of the same sex. However this may be, we have here a notable exception to the almost universal rule that the males depart further than the females from the common youthful form.

As our *Atyoida* differs in a whole series of peculiarities from the ordinary structure of the Prawns, such as *Palæmon*, *Hippo-*

* This number of bristles, which varies so much in *Atyoida Potimirim*, has been adopted by Heller in the case of the nearly allied genus *Caridina* among the generic characters; he ascribes to it nine setæ (Heller, *Crustaceen des südlichen Europa*, p. 238).

lyte, Alpheus, &c., so are species, genera, and families in general usually distinguished from their relatives and ancestors by numerous characters and not by a single one. And just as we can generally recognize no causal connexion between these various characters, so also in the case of *Atyoida* we should scarcely suspect anything of the kind,—for example, between the structure of the chelæ, that of the posterior maxillæ and the different armature of the carapace in the two sexes, had we only anatomized the dead animals. But so soon as we observe these little prawns living in all their activity, their mode of feeding at once explains the structure of their chelæ and buccal organs and their residence on plants, and this, again, the many-clawed fingers of their walking feet; we see how, as the structure of the chelæ renders them unsuitable for the cleansing of the branchial cavities, the form of the posterior maxillæ, which become adapted to this office, and the altered position of the first pair of swimming feet, come into connexion; the unarmed condition of the males enables us to understand their smaller size, and this again, the youthful structure of their carapace, &c. &c.; in short, all their manifold peculiarities at once come into the closest relation to one another, and we may hope that in many other cases, also, by careful observations of living animals, many apparently unconnected structures, for which at present a mysterious correlation of parts is made responsible, will come to be recognized as reciprocally causative results of Natural Selection.

THE MODE OF ACTION OF FACETTED EYES.

By PROFESSOR SIGMUND EXNER.*

IT is generally known that the organ of vision in the animal kingdom has been morphologically developed in two directions: in one direction to the eye of the vertebrate, in the other to the facetted eye. Quite recently, Grenacher's anatomical investigations have led to the discovery of the common starting-point of these two developmental forms, and to the tracing from it of the foundation of this sensory organ.† That the optical part of the eye of a vertebrate throws a picture of the objects in the outer world upon the retina, has long been known, and it may be demonstrated in the eye of any albino rabbit; that this picture has a physiological significance may be affirmed with certainty, for those rays, and only those rays, which produce a point of the retinal picture are those which lead to the perception of the corresponding points of the object. The picture is reversed.

Affairs are more complicated in the case of the facetted eye. Johannes Müller‡ was the first to assert that this eye also has a retinal picture, and that it is erect. The mode in which it is produced may be explained as follows:—If we imagine the insect eye deprived of the exquisite transparent structures, the cornea and crystalline cone, it may be conceived as a segment of a rather thick, hollow sphere, consisting of a pigmented mass, pierced by numerous close-set perforations running towards the centre of the sphere. If we further imagine the inner surface of the spherical segment coated with a membrane, it is clear that a picture of external objects must be produced upon the latter. Thus, as through the above perforations, only those rays can reach the membrane which run in, or nearly in, the axis of

* *Biologisches Centralblatt*, Juhrg. I. p. 272.

† *Untersuchungen über das Sehorgan der Arthropoden*, Göttingen, 1879.

‡ *Zur vergleichenden Physiologie des Gesichtssinns*, Leipzig, 1826.

the perforation, the portion of membrane which closes the perforation within can receive light only from a very limited direction. This direction is different for each perforation. If we draw the rays for the individual points of the object which run in the axis of the perforation, we see that they must produce an erect picture of it upon the supposed membrane. In reality, however, no membrane, in the ordinary sense of the word, is stretched over the inner apertures of the perforations, but the nervous elements, which in combination certainly form the retina, are implanted in the inner parts of the perforations.

From this we see at once that the facetted eyes of the two sides of an animal must command nearly the whole space around it; for each eye, by means of its curvature, commands more than the half of all possible directions, and the two eyes, in consequence of their position, reciprocally complete each other. A portion of any object at any time in the field of vision is simultaneously seen by both eyes. We see further from the imaginary picture above given, that the retinal picture, when compared with that of the vertebrate eye, will leave much to be desired in the matter of sharpness; that the sharpness will increase with the number of facets that come on the hemisphere; but that the strength of illumination of each retinal element will diminish as the number increases.

As regards the corneal facets and crystalline cones, these, according to Johannes Müller, produce no change in the nature of the eye, but rather serve only to increase the brightness of the whole picture.

This was the position of matters until the year 1852. Gottsche* then remarked that in the eye of a fly which had been freed from pigment by means of a cataract needle, a great number of minute pictures of external objects, showing considerable sharpness, could be detected under the microscope.† Each of them was situated over a facet of the cornea (the light coming from below towards the convexity of the cornea). These pictures were reversed. Gottsche thought at once that he had discovered the analogy with the eye of the vertebrate; each facet produced a retinal picture just like the vertebrate eye; but man had only two, and the fly several hundred eyes. A note of Johannes Müller's, appended by him to Gottsche's Memoir, appears to have been drawn up as if he agreed with Gottsche's ideas. In subsequent years a great number of authors, and among them Leydig‡ and Max Schultze,§ gave up

* Müller's *Archiv*, 1852.

† These pictures were previously known to Leeuwenhoek.

‡ *Das Auge der Gliederthiere*, 1864.

§ *Untersuchungen über die zusammengesetzten Augen der Krebse und Insekten*, Bonn, 1868.

Johannes Müller's theory of 'mosaic vision,' and, adopting Gottsche's interpretation, regarded each facet of the compound eye as an independent, perfect eye, possessing its retina and retinal picture.

In 1871, Boll,* chiefly supported by anatomical facts, first suggested a return to the old Müllerian views. He had remarked that, under favourable circumstances, small pictures of external objects can also be obtained through the rods (bacilli) of the retina of the newt, and his attention was then called to the physiological insignificance of such pictures. In point of fact, every fat-globule under the microscope shows comparatively sharp pictures.

Grenacher, who had published a preliminary statement of the results of his investigations in the *Göttinger Nachrichten*,† also opposed the interpretation of the facetted eyes in Gottsche's way, which had become general, and expressed himself in favour of Müller's theory. A year after the appearance of this preliminary statement, and unfortunately without any knowledge of it, I subjected the prevalent theory to a critical examination of a more physical character,‡ by studying the optical properties of a special example, the eye of the *Hydrophilus piceus*. It appeared to be exceedingly questionable whether the picture, which was supposed to be a retinal picture, was at all to be regarded as such optically; and further, that this picture, and especially that of the fly which Gottsche studied, does not exist at all during life. It is produced only when the crystalline cone is removed, and this was done by Gottsche. During life, when the crystalline cone lies behind the corneal facet, it cannot be produced.

On the contrary, I showed that the corneal facet and crystalline cone provide in the most remarkable manner for the bringing together, at the bottom of the crystalline cone, of a comparatively large number of the rays issuing from that point of the object that lies in the axis of a facet. The corneal facet acts in this case as a lens; and the crystalline cone by total reflection, as a catoptical apparatus. The rays which penetrate into it nearly parallel to its axis are, as it were, caught and conducted by reflection to its apex. Other rays, which enter at greater angles, may in part, by repeated reflections be rejected again without reaching the apex of the cone; part of them will pass the walls of the cone and be absorbed by the surrounding pigment, seeing that, at each reflection, the angle under which they strike the surface of the cone becomes greater.

* *Du Bois-Reymond und Reichert's Archiv*, 1871.

† 1874.

‡ *Ueber das Sehen von Bewegungen, und die Theorie des zusammengesetztes Anges, Wien. Akad. Sitzungsb.* 1875.

Endeavours to test the correctness of this view failed at first, owing to the impossibility of placing under the microscope crystalline cones and corneal facets of an eye in the normal position and under conditions corresponding to those of life. Nevertheless, this test could be carried out at least upon one animal, and it perfectly confirmed the above view. In the southern glow-worm (*Lampyris splendidula*) the crystalline cones are amalgamated with the corneal facets. If this eye is separated, completely freed from pigment by a hair-pencil, then laid with the corneal surface upon a perforated mica object-carrier so that the cornea closes the perforation, and then a drop of the beetle's blood is placed in the hollow of the eye, and over this a small film of mica, we have imitated as exactly as possible the natural conditions as regards refraction and reflection. If we then look down through the microscope upon this preparation,* we see an absolutely black surface, sprinkled with very bright points. The effect is so striking that one cannot help thinking that the object has not been freed from pigment. But if we turn it so that the light may fall perpendicularly to the axis of the cones, these are seen, like the corneæ, to be quite glassy and transparent, and perfectly free from pigment. This experiment shows, in fact, that the rays penetrating into the eye are guided by refraction and reflection to the apices of the crystalline cones; and that, if we leave out of consideration the small amounts that may return through the cornea, these are the only points in the whole optical system from which they can issue. There is nothing in the shape of a retinal picture in Gottsche's sense.

Although it may be hoped that Gottsche's theory is for ever disposed of, and that of Johannes Müller reinstated in its rights, a new question arises out of this very circumstance, namely, how are we to explain the fact that two sense-organs, developed for the same outward purpose, show such differences of structure as occur in the eye of the vertebrate and the facetted eye?

Upon this subject I have also set up an hypothesis. While making some physiological investigations upon the seeing of movements which, of course, related to the human eye, it struck me that the facetted eye was much more advantageously constructed for this special purpose than the vertebrate eye. From the important part performed in the animal world by the seeing of movements (the evidence of this is in my original memoir) it seems really not improbable that in it we have the clue to the comprehension of the insect eyes. This is the state of the

* Of course the plane mirror of the microscope must be employed in order to imitate the natural conditions.

case. Let a very small, bright point move before the eye of a vertebrate; the latter will observe the movement, for the retinal element (I take only one for the sake of simplicity), upon which the picture of the bright point first lay, loses its excitation, and in place of it the next one is excited, then, again, its neighbour, and so on. It is otherwise in the facetted eye. The structure of this is such that the light of the bright point penetrates into a whole group of facets, although in different quantities. The nerve-element of that facet, in the axis of which the bright point is situated, is most strongly excited; the neighbouring facets lying in a circle around this receive less light: the circle in contact with these externally still less, &c. If now the bright point moves, the excitation changes in all these facets, increasing in the one half and diminishing in the other. Hence such a movement will be a more striking phenomenon for the facetted eye than for the vertebrate eye. What is shown here in the case of a point of course applies to any moving object.

My notion, therefore is, that in the seeing of movements the facetted eye is superior to the eye of the vertebrate animal, but inferior to it in distinguishing objects—that is to say, in acuteness of vision.

A further investigation upon this subject is due to Oskar Schmidt.* In various crustacea and insects this observer found crystalline cones, which are by no means cones in a geometrical sense, but rather bent after the fashion of a horn. This was more particularly studied in *Phronima*. In consequence of this observation Schmidt also turned against Gottsche's conception of the eye, and in point of fact how should a picture be produced by refraction at the bottom of a bent cone?

Schmidt, however, regards his new observations as also incompatible with the other theory. He says: 'Nevertheless "mosaic vision" is also excluded in the case of *Phronima*, for the pre-supposed conditions for "mosaic vision," straightness of the axis of the refractive body, and absorption of the rays which enter laterally, do not occur here.'

I believe that O. Schmidt's interesting discovery contains a confirmation and not a refutation of the theory of 'mosaic vision,' for it is only compatible with this. The straightness of the axis of the cone is not in my judgment a necessary condition of 'mosaic vision,' and the absorption of laterally penetrating rays is not prevented by the curvature of the cone.

Imagine a cone with a straight axis, at the apex of which, therefore, as above explained, the rays which come approximately from the direction *a*, are brought together. If we now

* *Zeitschr. für wiss. Zool.* Bd. xxx. Suppl.

cut away the apex, and attach to the cut surface a curved transparent rod, all the rays which previously came together at the apex of the cone would penetrate into the rod, and be conducted further on in this rod, just as light-rays can be carried on in the interior of curved glass rods. O. Schmidt has himself made experiments of this kind. Some light will, of course, in general be lost in this process. This crystalline cone with the rod behaves now exactly like the curved crystalline cones of *Phronima*. Let us suppose that it conveys the light received from the direction *a* to the spot of the retina *a*, and then consider the neighbouring crystalline cone *b*. This may be so placed as regards its first portion and also its corneal facet, that, in accordance with the rules applying to the straight cones, it receives light from the direction *b*, which is close to the direction *a*, and then it will convey this light further on, however circuitous its course may be; and if its termination lies near *a*, it will deposit its light close to this upon the retinal spot *b*. In this way the different directions of space will be represented in the same order upon the retina. All that is necessary, therefore, for the production of a 'mosaic picture' is that each crystalline cone shall serve principally light of a particular direction, and that their extremities shall be placed in an order corresponding to this direction. According to the figures given by O. Schmidt these two conditions are perfectly fulfilled. Whether the light makes a circuitous route in the crystalline cone is a matter of subordinate consequence—nay, even the arrangement of their ends which are turned towards the light is quite indifferent, the direction of the axes of these ends is alone important. Could we seize an insect-eye with long filiform crystalline cones by the retina, and disarrange the individual cones, each with its cornea, as one can disarrange the threads of a tassel, we should obtain a 'mosaic picture,' in spite of all curvatures and the displacement of the free ends, provided always that the first part of the cone, with its corneal facet, had the same direction in space after the displacement as before.

As regards the absorption of laterally falling rays in the surrounding pigment, the curvature of the crystalline cone may doubtless cause many rays not to be absorbed which would otherwise be absorbed, and *vice versa;* the picture would thus lose somewhat in completeness, but why it should be destroyed is not easy to see.

Last year there appeared a monograph upon the visual perceptions which are performed by the facetted eye, by Notthaft.* The author occupied himself with the question of the sharpness

* *Abhandl. der Senckenb. naturf. Gesellsch.* Bd. xii.

of vision which may be assumed for various insect-eyes from their anatomical structure. As two neighbouring facets include between their axes very different angles in different animals, it is to be expected that this circumstance will correspond to an unequal sharpness of vision, and of course that the sharpness is greater, the smaller the angles. Further, however, I do not think we can go with him in his conclusions, especially as we do not know in how many of the individual facets some sensation is produced by light issuing from the same point. Notthaft gives figures, although with some reserve, which are intended to show the sharpness of the retinal picture of a given object. These have been constructed, however, upon the supposition that rays from one point only excite one retinal element of a facetted eye, a supposition as to which at present we know nothing.

I will here pass over much interesting detail that this Memoir contains, and pass at once to the kernel of it. This relates to the physiological interpretation of the facetted eye, and consists in the belief that by means of this eye the animal is able to estimate directly the distance of objects, just as is possible to the vertebrate eye.

Thus the picture of an object is supposed to diminish in brightness as the object is removed, and indeed the brightness is supposed to be in inverse proportion to the square of the distance. The proposition is expressed for the case of a definite hypothesis, which runs as follows :—'Upon every retinula there falls a cylindrical fascicle or line of light precisely in the direction of the optical axis of the element of the eye. The individual rays of light composing this fascicle maintain strictly the same direction. The portion of the object from which they issue and which occupies a single elementary field of vision, is consequently exactly of the same size for all distances, however different they may be; in fact it is exactly equal to the transverse section of the posterior, pointed, non-pigmented end of the crystalline cone, or to that of the retinula.'

Valuable as such a new point of view may appear for the understanding of the facetted eye, I cannot help protesting against it. Thus I regard the hypothesis which I have quoted above as perfectly unjustified. In the first place, it is not true that under the supposed circumstances the intensity of an illumination striking the retinula diminishes in the proportion of the square of the distance. It rather remains the same at all distances. This at once becomes clear if we go back upon the basis of the theory that light diffuses itself in all directions in rectilinear rays. The idea that lies at the foundation of this theory is, that the individual ray retains the same intensity in its whole course; the weakening of the illumination in

accordance with the square of the distance is therefore caused solely by the divergence of the rays. According to Notthaft's hypothesis only a single ray reaches each point of the retinula, and this consequently retains the same intensity whatever may be the distance of the object from which it comes; and as the number of rays which reach the retinula is also constant, its whole illumination by the admittedly parallel rays is independent of the distance; just as the variable distances within finite limits of an illuminated body from its infinitely distant source of light, have no influence upon the brightness of its illumination. (A body that is illuminated by the sun, which may be assumed to be at an infinite distance, is, *cæteris paribus*, equally bright, whether I place it on the table or on the floor.)

Secondly, Notthaft's hypothesis must be pronounced unjustifiable, even independently of the above-mentioned error.

In point of fact an optical apparatus which provides that only such light as has strictly the same direction at the optical axis shall fall upon the retinula (the surface of which turned towards the light has a finite extension) is inconceivable. Notthaft must have overlooked this difficulty and has thus been misled to his theory. Moreover, he himself upsets it, apparently without being quite clear about the matter, when, after explaining it, he speaks of the probable purpose of the spherical curvatures of the corneal facets, and on other occasions. Thus he himself demonstrates that both converging and diverging rays may reach the retinula. But as soon as any ray which does not run absolutely parallel to the axis of the ophthalmic element can give rise to the sense of light in it, the whole theory falls to the ground. The exposition which the author gives of the light-separating action of corneal facets is unsatisfactory, for in the example cited by him he overlooks the fact that if the corneal facet acts so as to throw one ray entering parallel to the axis to the right and another to the left wall of the crystalline cone, a ray falling obliquely to the axis must necessarily exist which will attain the apex of the crystalline cone.

I believe therefore that the theory of 'mosaic vision' is more firmly established than ever, and that there are no other data for the comprehension of the two divergent types of eyes than the above-mentioned notion of the superiority of the facetted eye in the seeing of movements. Notthaft has maintained that the insect when it moves, for example, when it flies, notwithstanding the supposed delicacy of its sensations of movement, must have difficulty in finding its true position in space. I think we may in this case appeal to the birds, which, during flight, and consequently while all objects must appear to travel past them with greater or less rapidity, nevertheless possess a

most admirable orientation. In all cases individual movement is a remarkable aid to the estimation of the distances of objects. In the latter connexion it may be mentioned that insects are at least so far superior to vertebrate animals in the estimation of distances, as with their two eyes they can see simultaneously a much larger portion of space.

REVIEWS.

AMERICAN SEAWEEDS.*

THIS Report is an attempt to present in a compact and more or less popular form a description of the different orders and species of seaweeds known to occur on the coast of the United States from Eastport (Maine) to New Jersey.

Since the publication of Harvey's classical *Nereis Boreali-Americana*, in the Smithsonian Contributions to Knowledge between 1852 and 1857, comparatively little has been added to our knowledge of the seaweeds of New England, the species recently discovered, with the exception of *Nemastoma Bairdii*, being mostly insignificant in size.

But during the last twenty years the great advance that has been made in the knowledge of the fructification and mode of growth of marine algæ, due to the researches of Thuret, Bornet, Areschoug and others, has entirely altered the bases of classification, and no book giving a good account of the modern views of the systematic arrangement and structure of algæ has, until now, been published in the English language.

The chapter devoted in the Report to this branch of the subject gives, in the short space of ten pages, a *resumé*, unequalled for clearness and masterly treatment, of the present views of the distinctive features of the different groups.

The classification is very similar to that published by Le Jolis in his *Liste des Algues Marines de Cherbourg*, but the Vaucheriæ, together with the Fucaceæ, are placed under the Oosporeæ, and the Bryopsideæ are raised to the rank of a sub-order, while the various families of the Florideæ are all described as sub-orders.

The introductory part contains much information concerning the geographical distribution of Algæ in North America, which cannot fail to be of interest to European algologists. Thus, the marine vegetation above Cape Cod is shown to be of a strongly marked arctic character, being a direct continuation of the flora of Greenland and Newfoundland; within a few miles of this arctic flora, and immediately to the south of that point, where the Gulf Stream diverges to the eastward, the Algæ are of a southern

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* *Marine Algæ of New England and Adjacent Coasts.* By G. W. J. Farlow, M.D. Reprinted from Report of the U. S. Fish Commission for 1879. Washington Government Printing Office, 1881.

character, insomuch that the Long Island flora has much in common with that of the Adriatic. Between Boston and Eastport all the predominating species are of the Scandinavian type, with the exception of *Agarum Turneri* and *Callithamnion Pylaisii:* these do not occur in Europe. The fact that *Phlæospora subarticulata* and *P. tortilis,* as well as several other plants common in Norway, have not yet been found on the New England coast, indicates that its Algæ have not been exhaustively examined. The absence of any members of the Dictyotaceæ, and of several Florideæ common in England, *e.g. Bonnemaisonia asparagoides* and *Plocamium coccineum,* is very remarkable. The genus Nitophyllum, too, is practically unknown anywhere on that portion of the Atlantic coast; and *Gelidium corneum,* a most variable species found in almost all parts of the world, is only occasionally met with, and then in the form separated by some algologists as a distinct species under the name of *G. crinale.* Of other Algæ, *Fucus canaliculatus, Himanthalia lorea,* the common European *Cystoseiræ,* and *Codium tomentosum,* are wanting, and *Fucus serratus* is very rare. On the other hand, some species, such as *Chordaria divaricata, Spyridia filamentosa,* and *Euthora cristata,* are more abundant on the coasts of New England than in Europe.

The influence of warmth on the determination of the character of the flora is well illustrated by the occurrence of the southern species, *Rhabdonia tenera, Gracilaria multipartita, Chondria Baileyana,* &c., in Goose Cove, an inlet dammed up at the entrance and only overflowed at high tides, and surrounded by an arctic flora on both sides, but in which the water is much warmer than that of the surrounding ocean. The plants must therefore have been carried over the dam by the tide, and grown in the cove simply because the water was sufficiently warm, in the same manner that in this country Mediterranean species are seen to be almost confined to sunny, shallow pools, where the water soon becomes of a temperature exceeding that of the deeper pools and of the neighbouring sea. But enough has been said to show the extreme interest of this portion of the work.

The systematic part, which naturally occupies the bulk of the report, is enriched by numerous explanatory notes, which exhibit not only an accurate acquaintance with the habits of the species in their own haunts, but an extended knowledge of the literature of each plant. Although the synonymy is very limited, it is sufficiently full to enable the reader to recognize the plants under the new names, where these have been altered during the last twenty years. In a few cases, but chiefly in those in which the author has not been able to examine living specimens of the plants, the most recent information is omitted; thus *Ectocarpus brachiatus,* Harv., has lately been referred to the genus *Phlæospora* by Bornet, and *Chætopteris plumosa* has been shown by Kjellman to have both unilocular and plurilocular sporangia on special branchlets, sometimes on the same and sometimes on distinct individuals; hence the statement that it has the unilocular sporangia on the ordinary branches must be incorrect, and can only refer to another plant resembling it in appearance, but which differs also in the absence of a distinct cortical layer in the stem.

The analyses of the genera and families at the commencement of each group, as well as the list of works consulted, form a useful addition; and the fifteen plates at the end of the Report, although somewhat crude in

execution, will serve to give a popular idea of the structure of the reproductive organs of the different groups. An artificial key to the genera, and a good index, complete a work that bids fair to be as popular on this side of the Atlantic as on the other, since the majority of species described in it are also natives of Britain; and the new classification and the explanatory notes will be an invaluable aid to English and North European students of algology.—E. M. HOLMES.

A GARDEN WILD.*

AT first sight we were inclined to think that the peculiar collocation of the words in the title of this book was simply a piece of affectation akin to that of the ballad-writers animadverted upon by Samuel Johnson,—

'Hermit hoar in solemn cell,
Wearing out life's evening gray,'

he said was an illustration of the style adopted by one of the fraternity of whom Boswell spoke with admiration; and, he added, he wouldn't say 'gray evening,' but 'evening gray' he would think was fine. This idea, however, although it applied in many cases, proved to have no sound foundation,—the 'wild' in the above title turned out to be a substantive, whilst 'garden' took on it an adjective signification; nay, the garden was often dropped altogether and the author spoke of it repeatedly as 'my wild.' One has heard tell of the wilds of America, but what is *a* wild? The fact is that what Mr. Heath describes is a wild garden of wild plants and the mode of its formation,—the artificial reproduction within an enclosed space of a small section of the open country,—and he has performed his task so well that one regrets that he has disfigured his book by its title.

Like so many other people who devote themselves to the promulgation of particular views, our author can see little or no good in practices other than those he recommends. Thus all the ordinary doings of the gardener are condemned *en masse*, except so far as they are directed to the production of food. The topiarian art, the art of topiary as Mr. Heath calls it, which was so highly esteemed among the ancient Romans, and has continued partially in vogue down to our own day, is, perhaps, justly placed at a very low standpoint,—cocks and peacocks, bears, foxes, and other animals clipped out of yew or box, are doubtless exceedingly absurd; but we are not prepared to admit that there is not a picturesque side to some of the other efforts of the topiarian artist.

If topiarianism has gone out, other horticultural practices have come into fashion which meet with very little favour at the hands of Mr. Heath. Bedding out and the formation of colour-beds and ribbon-borders he evidently regards with great contempt, and certainly, when adopted, as one often

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* *My Garden Wild, and what I grow there.* By Francis George Heath. Sm. 8vo. London: Chatto and Windus. 1881.

sees them, as the sole method of treatment of gardens of all sorts and sizes, they are liable to become absurd; but in larger and well-arranged grounds masses of colour are very effective, and Mr. Heath himself must admit that they are by no means unknown in nature. Florists' flowers, double flowers, and, in fact, all garden varieties of plants, are treated from a similar point of view,—all, in Mr. Heath's opinion, are mere monstrosities; and we are left to infer that therefore they can have no beauty in them,—a proposition from which we must beg leave to dissent. In fact, it seems to us that our author would have made his argument quite as strong and more acceptable had he omitted all reference to the 'false taste' of the ordinary horticulturist.

The true purpose of his book is the exposition of the course to be followed and the pleasure to be obtained in the formation of a wilderness of our native plants. He opens it with the description of a visit paid on a hot summer's day to the garden of a friend, laid out on the most approved modern model, followed by an account of a dream he had when, overcome by the heat and the brilliancy of the place, he dropped off to sleep in the friendly shelter of a handsome pagoda. In this dream was revealed to him in the most approved fashion, the beautiful result that might be produced by devoting a space of ground like that he had been inspecting to the production of a garden of plants in their natural wild state, and with their natural conditions of growth realized as far as possible.

Many of us, no doubt, have dreamt of delights of various kinds, but unfortunately all dreams are not prophetic. Mr. Heath, however, was lucky enough to arrive at the fulfilment of his vision, by acquiring a house with a large piece of ground attached to it which had not been disfigured by any of those horticultural abominations against which Mr. Heath's soul revolts. The previous occupier had simply planted a row of lime-trees round it, leaving the centre an expanse of gravel and turf, with a few shrubs. The presence of a small stream of water was a further advantage. Here, in fact, were all the elements required for carrying out the scheme, and Mr. Heath set to work upon it at once with his accustomed enthusiasm. In this little book we have the history of his proceedings told in his usual pleasant style. We shall not attempt to follow the author through the various details he gives for the guidance of such as may choose to devote the ground at their command, or a part of it, to the formation of a wild garden, but the enthusiasm with which Mr. Heath expounds his doings will no doubt lead many to wish, at any rate, to follow his example. For any one with a taste for botanical studies, no more interesting application of a bit of garden-ground could be suggested.

ILLUSIONS.*

ILLUSIONS are usually defined as sensations produced by a false perception of objects. When these false sensations are immediately detected

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* *Illusions.* By James Sully. Vol. xxxiv. International Scientific Series. London: C. Kegan Paul & Co. 8vo. 1881.

and not acted on as if real, the person subject to them is considered to be sane; when the illusion, however, is believed to have a real and positive existence, and this belief is not removed either by reflection or an appeal to the other senses, the individual is said to labour under a delusion. These distinctions, so well known to psychologists, are scarcely at all recognized as yet by the popular mind; and it is only through the instrumentality of works such as that which we have now under review, that we can hope to make them more generally understood.

As expressed by the author, 'Common sense knowing nothing of fine distinctions, is wont to draw a sharp line between the region of illusion and that of sane intelligence. To be the victim of an illusion is, in the popular judgment, to be excluded from the category of rational men.' Yet it must be granted 'that most men are sometimes liable to illusion.' 'A momentary fatigue of the nerves, a little mental excitement, a relaxation of the efforts of attention by which we continually take our bearings with respect to the real world about us, will produce just the same kind of confusion of reality and phantasms which we observe in the insane.' The term is used by the author in a wider sense than is usual with psychologists, and made to 'include under it errors which do not counterfeit actual perceptions.' For instance, by this popular extension of the term, a man is supposed to be 'under an illusion respecting himself when he has a ridiculously exaggerated view of his own importance;' and in a similar way of being 'in a state of illusion with respect to the past, when through frailty of memory he pictures it quite otherwise than it is certainly known to have been.'

The distinction between illusion and hallucination, or the sensations which are supposed to be produced by external impressions, although no material objects act upon the senses at the time, is not considered by the author to be very important; since in 'many cases it must be left an open question whether the error is to be classed as an illusion or as a hallucination.' Still, and we think wisely, 'the distinction is kept in view, and illustrated as far as possible.' Illusions are classified under the following heads:—Of Perception, Dreams, Illusions of Introspection, Errors of Insight, Illusions of Memory, and of Belief. The reader cannot fail to meet with much to interest him under each of the above heads. In the last chapter, entitled 'Results,' we are told that the study of illusions 'has tended to bring home to the mind the wide range of the illusory and unreal in our intellectual life;' but it is satisfactory to find further on that 'no doubt its grosser forms manifest themselves most conspicuously in the undisciplined mind of the savage and the rustic.'

A DICTIONARY OF CHEMISTRY.*

THE first volume of this work was published in 1863, or about eighteen years ago, and the concluding part of the Third Supplement now

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* *A Dictionary of Chemistry and the Allied Branches of other Sciences.* Third Supplement. Vol. III., Part 2. By Henry Watts. Longmans & Co.

before us brings the record of Chemical Discovery down to the end of the year 1879, including the more important discoveries which appeared in 1879 and 1880. Among the important articles in this final portion of the eighth volume are those on Gallium, Gases, Glycerine, Gold, Granite, Guano, Gypsum, Heat, Hornblende, Hydrocarbons, Iodine, Iron, Isomerism, Lead, Light, Magnetism, Manganese, Mercury and Mercury Compounds, Meteorites, Methyl and Methyl Derivatives, Mica, Milk, Molybdenum, Napthlenes, Nicotine, Nitrifications, Nitrates, Oils, Olivine, Organic Compounds, Paraffin, Petroleum, Phenol, Phosphorus, Phosphates, Platinum, Pyroxene, Resin, Selenium, Serpentine, Silver, Soda, Spectral Analysis, Starch, Sugars, Sulphides, Sulphur, Sulphuric Acid and Sulphates, Tellurium, Thermodynamics, Tin, Titanium, Toluenes, Trachyte, Tungsten, Vanadium, Vapour-Density, Volcanic Products, Yttrium Metals and Zeolites.

Chemical research has been unusually active during the eighteen years this Dictionary was in course of preparation, and has resulted in such a mass of facts that in order to record them fairly it has been necessary to extend the work to over ten thousand five hundred closely printed octavo pages.

The time which has elapsed since the appearance of the first volume has also necessitated the addition of various comprehensive supplements, since, in order to bring down the information to date, three or more successive articles on the same subject have sometimes been required. In no case, however, has the same matter been reprinted, and consequently by taking the various articles in the order of their sequence, the student has laid before him a continuous history of the subject under consideration.

Dr. Watts has performed his task with great care and industry, and has produced a work, which, furnishing, as it does, a complete epitome of the science of which it treats, should be accessible to every advanced student of chemistry. This work is not, however, entirely free from slight blemishes, among which may sometimes be observed evidences of careful compilation rather than of the exercise of an intelligent discrimination with regard to the relative values of the different processes described.

As an example of this want of appreciation, attention may be directed to the article Silver, in which we are told that two methods are employed for the removal of that metal from solutions obtained by the lixiviation of burnt cupreous iron pyrites, namely, Claudet's process, which depends on the almost complete insolubility of iodide of silver in solutions of metallic and alkaline chlorides, and Gibbs', which consists of blowing through the copper liquors a mixture of air and sulphuretted hydrogen, when the first precipitate obtained contains a larger proportion of silver than that subsequently produced. The cost and the production of the two processes are represented as being the same, and the student will naturally infer that they are equally valuable.

As a matter of fact, however, Claudet's process is, without exception, universally employed, while the other, although experimentally tried for a short time, was found commercially unsuccessful. Such occasional inaccuracies will doubtless be corrected in a second edition.

THE MICROGRAPHIC DICTIONARY.*

WE are happy to see that after an interval of ten years the *Micrographic Dictionary* has entered upon a new lease of its existence, the first three parts of its fourth edition having just made their appearance. The book is expected to be completed in twenty-one monthly parts. Of a work so well known and so highly appreciated, it is hardly necessary for us to say anything; but for the benefit of such readers as may be unacquainted with the former issues, we may venture to indicate, in general terms, what is the nature of the book.

The main purpose of the original authors, Dr. Griffith and the late Prof. Henfrey was to give, in a series of alphabetically arranged articles, a summary of information necessary or useful to microscopists, especially in relation to the microscopic forms of animal and vegetable life, and those details of minute structure in the larger organisms, for the examination of which the employment of the microscope is necessary. These articles were very copiously illustrated, partly with plates, containing an immense number of figures, mostly coloured, and partly with numerous woodcuts. By the insertion of articles indicating a scheme of classification for the organisms referred to, with numerous cross-references, provision was made to enable the student to work out the objects systematically, thus, as far as possible, combining the advantages of dictionary arrangement with those of a systematic treatise. Further the authors prefixed to their Dictionary a general account of the microscope and its accessories, and of the mode of using them; while in the body of the work they introduced many articles relating to special points connected with the structure or use of the microscope, such as angular aperture, polarization of light, preparation and preservation of objects, test-objects, &c. By a judicious system of bibliographical references appended to each article, the reader was always told where he could find further information upon the subject if he required it; and thus between the knowledge directly conveyed by it, and its indications of other sources of information, the work was rendered a most useful and valuable summary of all matters connected with microscopic studies.

In the second edition, which was just completed at the time of Prof. Henfrey's lamented death, the authors made very great additions and improvements upon their work: many additional illustrations were given, and while the original design was closely adhered to, it was more thoroughly carried out, and the value of the book, which was much enlarged, was greatly increased. The third edition, in the preparation of which Dr. Griffith was aided by Prof. Duncan, in addition to his present assistants, was a still further improvement upon its predecessors; and from the inspection of the few numbers of the fourth which have reached us, it would appear that the author is strictly following out the same mode of treatment. In its present form the *Micrographic Dictionary* may be regarded as an Encyclo-

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* *The Micrographic Dictionary; a Guide to the Examination and Investigation of Structure and Nature of Microscopic Objects.* By J. W. Griffith, M.D., &c., and Arthur Henfrey, F.R.S., &c. Fourth edition. Edited by J. W. Griffith, M.D., &c., assisted by the Rev. M. J. Berkeley, M.A., and T. Rupert Jones, F.R.S. Parts I. to III. 8vo, London. Van Voorst, 1881.

pædia of minute Natural History, which we heartily recommend as an invaluable handbook to all students, especially to those who, from isolation or other causes, are debarred from access to large libraries.

GLASGOW GEOLOGY.*

THIS work consists of a series of sketches and other papers illustrative of the geology around Glasgow, based upon notes of excursions, which appeared in the local journals from time to time. These have now been carefully revised, and in many parts extended, so as to afford a popular and fairly accurate idea of the geological structure and of the principal features of interest which the rocks of the district present.

Within the area described, as shown by the accompanying geological map, the chief strata are of Palæozoic age, with their contemporaneous and intrusive igneous rocks, covered, however, in many places by a considerable thickness of post-tertiary deposits, formed during the glacial period, the effects of which, and the accumulations resulting therefrom, are fully explained in some of the chapters. In the other chapters are described the various subdivisions and characters of the Old Red Sandstone and Carboniferous series, the latter of which with the associated volcanic lavas and ashes form so important a feature of the geology around Glasgow.

This series of excursion-sketches, with the intercalated historical notices, now issued in a collected form, will be an especially useful guide to those interested in Geology who may pay a passing visit to the district.

THE MICROSCOPE.†

DR. CARPENTER'S manual of the microscope is so well known, that we need hardly do more than call the reader's attention to the publication of a new and enlarged edition, the sixth that has appeared. The book has now increased to some nine hundred pages, and, judging from an inspection of its contents, the veteran author has used every endeavour to render it as complete as possible. The plan of the work continues exactly the same as in former editions, but an immense quantity of new information has been put into it, both in the portion relating to the microscopic investigation of plants and animals, and in that treating of the structure and use of the microscope and its accessories, and the preparation of objects for exami-

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* *Among the Rocks around Glasgow.* By Dugald Bell. 8vo. Glasgow: James Maclose, 1881.

† *The Microscope and its Revelations.* By W. B. Carpenter, C.B., M.D., &c. Sixth edition. Sm. 8vo. London, Churchill, 1881.

nation. In the latter department the activity of microscopists has been of late so great that the task of selecting useful apparatus and processes from the multitude of things recommended with more or less reason in every publication devoted to the interests of microscopists, must have been no light task; and although it is quite possible that Dr. Carpenter may have omitted some details that might put in a claim to notice, his book is in this department wonderfully up to date. We notice many things, especially in the way of apparatus, which seem to have been only just brought before the microscopic world.

In this edition some little notice is given to the important applications of the microscope in geological, and especially in petrological investigations; want of space, probably quite as much as the necessity for special mineralogical knowledge on the part of the reader, inducing Dr. Carpenter to cut what he has to say upon this department of his subject very short indeed. Considering the extent to which petrology is pushing into the front of geological research in the present day, one would be glad to see its principles treated at somewhat greater length in such a book as this of Dr. Carpenter's; at the same time, his brief statement, accompanied as it is by references to works in which the student may find further information, is always a step in the right direction.

FLOATING GERMS.*

IN view, probably, of the meeting of the International Medical Congress, which has recently been held in London, Prof. Tyndall has collected, in a small octavo volume, some half-dozen of his memoirs on the floating particles so abundant in the air, and which he has made out to play so important a part in many ways. We have here the full description of those numerous and elaborate experiments which the author made for the purpose of demonstrating the organic nature of some of the constituents of the atmospheric dust, and their influence in producing putrefaction associated with the growth of Bacteria in organic infusions, experiments which have always seemed to us to prove most satisfactorily the thesis which the author had set before him. Indeed, the experiments of Pasteur, which now date back a good many years, would, one might think, have been regarded as conclusive.

Nevertheless, the doctrine of spontaneous generation still retains a certain amount of vitality, and Dr. Bastian especially maintains it with great vigour. This doctrine, and the arguments of its supporters, are discussed at considerable length by Prof. Tyndall in more than one of these papers, and it seems to us that he has fully demonstrated its untenability. The *coup de grâce* seems to be given to all arguments in its favour, founded upon assumed imperfections in the result of previous experiments of its opponents,

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* *Essays on the Floating matter of the Air in Relation to Putrefaction and Infection.* By John Tyndall, F.R.S. 8vo. London: Longmans, 1881.

by the system of 'discontinuous boiling' adopted by the author in the case of certain exceedingly 'obdurate germs,' such as the spores of the hay bacillus, which, 'when thoroughly desiccated by age, have withstood the ordeal' of boiling for eight hours. Prof. Tyndall assumed that these desiccated germs resist the effects of heat by reason of their desiccated condition, and that before developing a crop of Bacteria in any infusion, they must necessarily pass into a soft and plastic state. Accordingly having set aside an infusion, undoubtedly infected by some of the most resistant germs, for ten or twelve hours, he then raised its temperature to the boiling point, and set it aside once more. By a repetition of this process the germs as they successively advanced towards the stage of active development, were caught and destroyed by the boiling temperature 'in the order of their resistance'—in fact, the Professor effected a sort of fractional destruction of them, and by repeating the process a sufficient number of times his infusions were all completely disinfected. 'Not one of them,' he says, 'bore the ordeal;' and the sum of the exposures to a boiling temperature did not exceed a few minutes.

We shall not follow Prof. Tyndall into the discussion of what is the most important outcome of these researches into the nature of the atmospheric dust, namely, the germ-theory of disease, to which he naturally devotes a good deal of space in this volume; by many medical men the matter is regarded as settled, and the rest of the profession will probably soon adopt the new faith. Upon all the leading points connected with it the reader will find in this volume an excellent summary of information, besides the details of experimental investigations, to which we have already alluded; and although some of the papers are communicated to the Royal Society, the unlearned reader need not on that account dread being unable to understand them.

BRITISH MARINE MAMMALS.*

MR. SOUTHWELL has published a popular account of the Marine Mammalia which have been found in the British Seas, and, although it contains nothing particularly novel, it will serve to furnish general readers with accurate information, pleasantly communicated, upon a subject of which general readers are commonly profoundly ignorant. Mr. Southwell carefully avoids any display of scientific phraseology, but he describes the general characters of the animals referred to with sufficient exactitude to give his readers a good notion of their appearance, especially in conjunction with the woodcut figures which accompany the notices, and which are generally very fairly executed. The information as to the habits and distribution of the species seems to have been carefully got together and from recent sources, and altogether we can recommend Mr. Southwell's book as a very satisfactory contribution to the Popular Natural History of these Islands.

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* *The Seals and Whales of the British Seas.* By Thomas Southwell, F.Z.S. Sm. 4to. London: Jarrold & Sons, 1881.

A ZOOLOGICAL ATLAS.*

SOME twelve months ago we noticed the appearance of a 'Biological Atlas,' by Messrs. A. M. & D. McAlpine, in which the authors, by means of a series of coloured plates, endeavoured to furnish illustrations of a course of lessons in Biology, following the general treatment adopted by Prof. Huxley, upon whose lectures, indeed, the plan of the work was founded. One of the authors has now commenced the publication of a more extended work of the same kind, the first portion of which, treating of the Vertebrata, contains twenty-four large plates with numerous figures showing the external form and internal structure of a selected series of vertebrate types. We presume the invertebrate groups are to follow.

The author here describes and figures the component structures of six vertebrate animals, and in his selection of the types he has to a certain extent been guided by the consideration that the animals should be easily procurable. Thus of the Fishes we have the Skate and Codfish as examples of Selachian and bony fishes respectively; the Salamander is taken as the type of the Batrachia because, although not a British species, it can easily be purchased; the common Land Tortoise serves as an example of Reptiles, a selection which is hardly a good one; and for Birds and Mammals we have the Pigeon and the Rabbit.

Directions are given for dissecting these various forms of Vertebrates, and the structures brought to light are very clearly shown in the numerous figures. The plates seem to us to be better than those in the former Atlas.

NORTH AMERICAN RHIZOPODS.†

NOT long since we had the pleasure of noticing the appearance of an admirable work on the Fresh-water Rhizopoda of North America, by Prof. Leidy, published as a volume of the quarto Reports of the United States Geological Survey of the Territories. Notwithstanding some defects, this treatise was undoubtedly a most valuable contribution to the zoology of the Protozoa, and one can only regret that there is in this country no machinery by the agency of which such books might be enabled to see the light.

There is a proverb which says that a prophet shall be without honour in his own country. The United States may probably constitute an exception; if not, Prof. Leidy may pass as the exception that proves the rule. At any rate his book has received the honour of being summarized in a very neat little octavo volume by Mr. Romyn Hitchcock, who gives, as it were, the

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* *Zoological Atlas (including Comparative Anatomy), with Practical Directions and Explanatory Text.* By D. McAlpine, F.G.S. Vertebrata. Oblong 4to. W. & A. K. Johnstone, Edinburgh and London, 1881.

† *Synopsis of the Fresh-water Rhizopods.* A condensed account of the genera and species, founded upon Prof. Joseph Leidy's *Fresh-water Rhizopods of North America.* Compiled by Romyn Hitchcock. 8vo. New York, R. Hitchcock, 1881.

skeleton of the larger treatise in a very convenient form for the use of students. In this little work, Mr. Hitchcock has abstracted from Prof. Leidy's work the characters of the various groups, genera, and species, bringing them into the form of short definitions, but adhering, as far as possible, to the language of the original. The genera and species are tabulated. The work seems to have been most carefully executed; and the little book, which consists of only sixty-four pages, including the introduction and index, will form a most excellent and portable hand-book, serving in fact in place of those notes which a student of Rhizopods would like to make for himself of such a bulky volume as Prof. Leidy's. The only thing that could add to its usefulness could be a couple of plates of outline figures illustrating the forms of animals described; such figures are always a great assistance, especially to beginners.

SCIENTIFIC SUMMARY.

ASTRONOMY.

Recent determination of the Solar Parallax.—Lately there has been published in the *Memoirs of the Royal Astronomical Society*, an account of the final results of the expedition to the Island of Ascension, in 1877, organized by Mr. David Gill, now Her Majesty's Astronomer at the Cape of Good Hope, for the determination of the distance of the Sun by means of heliometer measurements of the distance of the planet *Mars* from a number of small stars in its neighbourhood. The investigation now published is very elaborate, care having been taken to discuss all the probable sources of error, so as to show that they cannot have had any effect on the result.

The final results may be summed up as follows:—

Value of the constant of the solar parallax when only symmetrically placed observations are employed, and certain doubtful observations rejected,—

$$\pi = 8''{\cdot}778 \pm 0''{\cdot}012.$$

Value of the constant of the solar parallax when all the observations are employed,—

$$\pi = 8''{\cdot}783 \pm 0''{\cdot}026.$$

The mean may be taken as,—

$$\pi = 8''{\cdot}78 \pm 0''{\cdot}012.$$

This value corresponds to a distance of the Sun of—

93,080,000 miles.

This value is much smaller than any other important determination that has yet been made, but is confirmed to a certain extent by recent determinations of the velocity of light, taken in conjunction with the best values for the constant of aberration.

Recently M. V. Puiseux (*Comptes Rendus*, March 7th, 1881) has published an account of the results of the observations made by the French observers at the Transit of *Venus*, on December 8th, 1874. The time of the passage of the planet over the Sun was observed by eight astronomers at five different stations, namely, Pekin, St. Paul's, Nagasaki, Saigon, and Kobé, and when these are compared, they lead to a value for the constant of the solar parallax of—

$$\pi = 8''{\cdot}96 \pm 0''{\cdot}010.$$

It will be remembered that the results of the English observations, which were founded on the time at which the planet touched the limb of the Sun, and not on the duration of the transit, gave results of little value, for by putting perfectly reasonable but somewhat different interpretations on the descriptions given by different observers, there could be obtained any value of the solar parallax between—

$$\pi = 8''{\cdot}90.$$

and—

$$\pi = 8''{\cdot}75.$$

Mr. Stone has criticised the results given by M. Puiseux (*Monthly Notices*, April 1881), and he is of the opinion that two of these durations, namely, those of MM. Janssen and Tisserand, must be rejected as incompatible with the interpretation placed on them. The remaining six then give a value of the constant of the solar parallax of—

$$\pi = 8''{\cdot}88.$$

The English photographs of the Transit of *Venus* failed totally, as had been predicted by more than one astronomer before the Expedition went out in 1874. The Americans relied on another method of applying photography to this purpose, and they seem to have obtained results of far greater accuracy. Lately, Mr. D. P. Todd, of Washington, has published an account of the results which have been so far obtained. At the three northern stations, Wladiwastock, Nagasaki, and Pekin, eighty-four photographs were obtained; and at the five southern stations, Kerguelen Island, Hobart Town, Campbelltown, Queenstown, and Chatham Island, 131 photographs were obtained. From a discussion of the distances of *Venus* from the centre of the Sun, the value of the solar parallax was found to be—

$$\pi = 8''{\cdot}888 \pm 0''{\cdot}042.$$

From a discussion of the position angle at which *Venus* was situated, there was obtained the value,—

$$\pi = 8''{\cdot}873 \pm 0''{\cdot}060.$$

From both classes of observations the result is—

$$\pi = 8''{\cdot}883 \pm 0''{\cdot}034,$$

corresponding to a distance of the Sun from the Earth of—

92,028,000 miles.

It will be seen, therefore, that the results obtained by these two methods, the Transit of *Venus* and Opposition of *Mars*, give results differing by more than a million of miles, and much remains to be done before the value of the solar parallax, or distance of the Sun, can be regarded as known with any degree of certainty.

In the meantime, other and improved methods of determining this important factor continue to be carried on. Prof. Newcomb is engaged on a new determination of the velocity of light; Mr. Gill is understood to be engaged on preparations for a new determination of the parallax from observations of the minor planets; at Pulkowa there is being made a fresh determination of the time taken by light to traverse the terrestrial orbit, from the data afforded by the observations of the eclipses of *Jupiter's* satellites;

Mr. Neison is engaged in determining the solar parallax from a new class of inequalities in the motion of the Moon; Messrs. Neison and Campbell, by means of a new determination of the parallactic inequality, by a method which is independent of the diameter of the Moon; and Prof. Winnecke, by a method founded on observations of the distance of the planet *Venus* from small stars, when near its greatest elongation.

Jupiter.—The planet *Jupiter* is again coming into a convenient position for observation, and it is probable that during the coming opposition further important contributions to our knowledge of its physical condition will be obtained. The great red spot still remains visible and apparently unchanged, and it crosses the centre of the disk of the planet within a few minutes of the time predicted by Mr. Marth, so that its period of rotation remains unchanged, and is not slowly altering, as was surmised by several observers early last year. White equatorial spots are again visible, having a swifter rotation than the red spot. The dark spots do not seem to be nearly so intense as during the early part of the year.

The Comets.—This year has been a peculiarly fortunate year as far as comets have been concerned, no less than four having been already observed, and two of these comets of considerable brightness.

Comet b, 1881.—This bright comet was discovered in the Southern Hemisphere, and was at first believed to be a return of the great comet of 1807, a view quickly found to be incorrect. In June it made its appearance above the northern horizon, and for some time remained a conspicuous object, having a bright nucleus and a tail of considerable length. Numerous sketches were made of its appearance and the usual evidences of apparent changes were seen, though, from the immense extent of these changes, it is at times difficult to believe that they can be other than optical. From his observations with the polariscope, Prof. A. Wright, of Washington, is of the opinion that the greater amount of the light reaching us from the tail of the comet is merely reflected solar light. Prof. Young, of Princetown, considers, from spectroscopic observation, that we thus have almost overpowering evidence that the gaseous substance of this comet is a hydrocarbon, and in a molecular state corresponding to that at the base of a gas-flame. It is not necessarily at a very high temperature, since the experiments of Wiederman, Hasselberg, and others, tend to show that under certain circumstances gases may become luminous, and give their characteristic band-spectrum at temperatures even below that of boiling water. Indeed, the dynamical theory of gases would show that all gases at any temperature must be, to a certain extent, luminous, and give a spectrum if seen in sufficiently thick strata, whatever may be their temperature, an increase of temperature merely increasing the amount of light coming from any mass of gas.

Prof. Henry Draper, of New York, obtained a number of photographs of the comet,—one with an exposure of $2^h\ 42^m$, showing a very dense nucleus and a tail about 10° long: on this photograph a number of very small stars are to be seen, some shining through the central portion of the tail of the comet. Mr. A. A. Common, of Ealing, also succeeded in obtaining photographs of this comet with his great 37-inch reflector, but with less success, having been unable to employ so long an exposure.

Dr. Huggins has obtained photographs of the spectrum of the comet, and

he is of opinion that these photographs show the bands in the spectrum, which are regarded by Profs. Dewar and Livering as proving the presence of nitrogen as well as of carbon. In this case, all these elements, hydrogen, nitrogen, and carbon, may be present in different combinations, such as cyanogen, or prussic acid, in the tail of the comet. If this view be really true, it might lend a terrible significance to comets, and the passage of the Earth through the tail of a comet might have the most frighful consequences to us terrestrial inhabitants.

The nucleus of the comet passed quite close to two stars of tolerable brightness, one on June 29th, when the nucleus passed within 18″ of the star *Radcliffe* 1661, and on July 13th, within 32″ of the sixth-magnitude star, 56 *Tauri*. The intensity of the light of this last star was considerably greater than that of the nucleus of the comet, though, from its superior size, the comet was much brighter to the unassisted eye. This comet continued to be visible until September.

Comet c, 1881.—This comet was discovered by Mr. Schäberle, and gradually became bright, until it was nearly as bright as the preceding comet; indeed, the light of the nucleus seems to have been brighter, but the tail was not so distinct. On August 10th it approached very close to the third-magnitude star *θ Ursæ Majoris*, and to the naked eye the nucleus of the comet seemed as bright as the star, whilst the tail had a length of nearly 10°. The comet has now swept into a favourable position for observation in the Southern Hemisphere. It appears to be moving in a very similar orbit to that of a preceding comet.

Encke's Comet. Comet d, 1881.—This periodical comet has again been observed on its return, it having been discovered on August 25th, by Dr. Hartwig at Strasburg, and Herr Block at Pulkowa; and on August 27th, by Mr. Common at Ealing. It is a faint, nebulous object, about 2′ in diameter, and quite close to its predicted place. Towards the end of October it will probably be just visible to the naked eye.

Cape Catalogue of Stars.—Mr. Stone, late Her Majesty's Astronomer at the Cape of Good Hope, has just completed his great Catalogue of Southern Stars, the result of his ten years' labour at the Cape of Good Hope. It forms a goodly volume and a valuable contribution to this branch of Astronomy. It is understood that it is to be supplemented by a determination of the proper motion of the principal Southern stars.

Resignation of Sir G. Airy, K.C.B.—The most important event in the astronomical world has been the resignation of the Astronomer Royal, Sir George Biddell Airy, K.C.B., F.R.S., his resignation taking effect on August 1st, or nearly on the completion of his forty-sixth year of labour, he having been appointed on October 2nd, 1835. Sir G. Airy will thus have held office for a longer period than any of his predecessors, though only for a few months longer than both Maskelyne and Flamsteed. Sir G. Airy, who came to Greenwich with a distinguished reputation, owing to his numerous brilliant investigations whilst holding the appointment of Director of the Observatory at Cambridge, has not disappointed the expectations which were aroused on his appointment, and during the entire period it has been under his control the Royal Observatory has deservedly ranked at the head of the existing Meridional Observatories. It is almost impossible to over-estimate the value

of the long series of observations which have been made under his direction, and carefully reduced with the greatest care, and on a uniform principle, under his immediate superintendence. The Greenwich Observations afford an immense mass of thoroughly reduced observations of the Sun, Moon, planets, and stars, such as do not exist anywhere else, and on which will be founded in the future, as they have been in the past, the greatest improvements in Astronomy.

Apart from the routine work attaching to his duties, first as Director of the Cambridge Observatory and afterwards as Astronomer Royal, and therefore head of the Royal Observatory, Greenwich, the principal astronomical labours which have been successfully undertaken by Sir. George Airy are as follows:—The determination of the long inequality in the motion of the Earth, due to the attraction of the planet *Venus*, and depending for its importance on the fact that every thirteen years *Venus* and the Earth come back to almost the same position with regard to each other. The reduction of the Greenwich Planetary Observations from 1750 to 1831, thus placing an immense mass of observations of the planets, all carefully reduced on a uniform system, at the disposal of the theorist who wishes to improve the tables of the planets by perfecting the theory of their motion. Since 1751, all the observations of the planets made at Greenwich have been carefully reduced on the same system, so that at present a long mass of observations are available, ranging from 1751 to 1881. Before this was done every mathematical astronomer had to reduce the observations for himself, adding most enormous amounts of arithmetical drudgery to his other labours. The reduction of the Greewich Lunar Observations, from 1751 to 1831, and subsequently the extension of this labour up to 1851. This was a still more laborious and important labour than the last. It is true that up to the present time it has not been employed in the manner that might have been anticipated, as Hansen's Tables were not founded on this great work, being partially constructed before it appeared, and no new lunar tables of any importance have since been constructed.

Besides these great works, numerous contributions to the advancement of Astronomy are due to Sir G. Airy, such as the publication of Groombridge's Catalogue of Circumpolar Stars; several expeditions to observe Total Eclipses; the Transit of *Venus* Expedition of 1874; &c. &c.

Mr. W. H. M. Christie, late the principal Assistant at Greenwich, has been appointed the new Astronomer Royal, with Mr. E. Dunkin as his principal Assistant.

BOTANY.

Reproduction of the Unicellular Algæ.—G. Klebs has communicated to the *Botanische Zeitung* (1881, Nos. 18–21) an article on the development of numerous unicellular Algæ, generally grouped as Protococcaceæ. In the forms here described, the development is essentially similar; all of them are strictly unicellular; no vegetative division occurs; each cell lives for itself, and at its period of maturity forms a number of daughter-cells,

generally zoospores, each of which of itself (or when a copulation takes place the product of this process) grows into an individual like the parent cell. In external form and internal structure, these Algæ are very similar; the principal differences between them are manifested in the particular features of the development, and especially in sexual fertilization. One of them, *Scotinosphæra parodoxa*, is decidedly asexual, if a two years' cultivation may be decisive upon this point; this Alga possesses a special peculiarity, the structure of the constantly asexual zoospores. The cell, at its maturity, shows a differentiation of the green protoplasm into numerous cylindrical rods; these gradually fuse together, during which process a red plasmatic granular matter is separated. The final result is the formation of a single dark-green sphere in the midst of the red granular matter; this sphere immediately begins to divide again, and by repeated divisions, during which the red matter is again taken up, the asexual zoospores are produced.

The simplest process of sexual fertilization is exhibited by two other Algæ, *Chlorochytrium Lemnæ* and *Endosphæra biennis*. In these the zoospores, which are produced simply by repeated binary division, always conjugate in pairs, which originate from the same mother-cell; only the product thus formed is capable of propagating the species. In *Chlorochytrium*, in the course of the summer many of these sexual generations are successively produced, and the generation first exposed to the influence of winter falls into a resting state; in *Endosphæra*, on the contrary, each generation requires a whole year for its development. This simplest possible form of reproduction by self-fecundation was previously known only in *Actinosphærium Eichhornii*.

A perceptible differentiation of the two conjugating sexual cells makes its appearance in *Phyllobium dimorphum*, which lives during the summer in the leaves of *Lysimachia nummularia*, in the form of green branching tubes. Some of the cells form large, and the others small zoospores, and only the product of the conjugation of a large one with a small one is susceptible of development. Some other peculiarities occur, which show upon how low a grade of development the several phenomena are in these green unicellular Algæ; nay, even their constancy in the same species, or at any rate in very nearly allied forms, is but slight. In the genus *Chlorochytrium*, besides the distinctly sexual species, *C. Lemnæ*, there are other species in which the course of development is otherwise exactly the same, but the zoospores never conjugate; each of them is capable of continuing the species. In *Phyllobium*, also, species are known (one of them is described as *P. incertum*) which are reproduced only by asexual zoospores, and it is interesting to find that the decidedly sexual *P. dimorphum* may also, under certain circumstances, lose its sexuality, and become an asexually reproductive form.

The Algæ described have one biological peculiarity in common,—they do not live in the water but in other plants, some in dead, some in dying, and some only in living parts. The author does not think that these and similar Algæ can be regarded as parasites, but that the plants merely seek shelter within the organisms they infest.

CHEMISTRY.

Ozone as a Cause of the Luminosity of Phosphorus.—Various writers, and especially Joubert, have called attention to the connexion of the phenomena of phosphorescence with ozone. To learn something of the nature of this connexion, Chappuis has studied the effect of ozone upon the luminosity of phosphorus in the presence of oxygen. Fourcroy long since observed that in pure oxygen, at a temperature of 15° C., and under atmospheric pressure, phosphorus is not luminous in the dark. Chappuis now finds that under these conditions a bubble of ozone introduced into the bell-jar produces phosphorescence, though only momentarily, the ozone being destroyed. Moreover, it is not the vaporization of the phosphorus which determines the phosphorescence, but the combustion of this vapour, the entire space occupied by the oxygen at first appearing luminous, the solid becoming so only after all the vapour has been burned by the ozone. Two cylinders, one containing air, the other pure oxygen, were inverted over two dishes containing potassium iodide and starch solution; a fragment of phosphorus was plunged into each gas in contact with the liquid. In the first the phosphorus became luminous, and the solution became blue. In the second neither phenomenon appeared. Whenever the phosphorescence appeared ozone was present; and whenever ozone was absent there was no luminosity. Moreover, the author calls attention to the fact that certain bodies which have the power of promoting this luminosity of phosphorus are precisely those bodies which destroy ozone or are destroyed by it. Oil of turpentine, for example, which is the most active, destroys ozone completely. In a balloon containing air, phosphorus, and turpentine, a bubble of ozone produces light for a second only, the ozone being destroyed by the turpentine, but burning a part of the phosphorus-vapour also. On adding the ozone the luminosity extends throughout the space, and at last the solid phosphorus only remains luminous. Hence M. Chappuis regards the production of the luminosity of phosphorus in oxygen as one of the most delicate of the reactions for ozone, and proposes to employ it in subsequent researches.—(*Bull. Soc. Chim.: Amer. Journ. Soc., August*, 1881.)

A supposed New Metal.—Mr. T. L. Phipson, from some experiments of his, infers the existence in commercial zinc of a new metallic element, to which he proposes to give the name of *Actinium*, on account of certain actinic phenomena of which he assumes it to be the cause. He says that the white sulphide of zinc prepared by precipitating the solution of the commercial metal with sulphide of barium, and washing, drying, and calcining the precipitate, sometimes possesses the curious property of changing colour under the influence of the direct rays of the sun, becoming first brown, and finally slaty-black, in from twenty to thirty minutes, but resuming its white colour when placed in darkness. Contact with air is necessary for the production of the changes of colour, and the intervention of a piece of glass prevents the blackening from taking place. The supposed new metal is characterized by Mr. Phipson as having a white sulphide, rendered black by the reducing action of the solar rays, and becoming white again in the dark by oxidation. (*Comptes Rendus*, August 22nd, 1881.)

New treatment of Sulphur.—MM. de la Tour du Breuil suggest (*Comptes*

Rendus, September 12, 1881) an improvement in the method of separating sulphur from its gangue. The old method was so wasteful, that attempts were made by means of hot air and superheated steam to get rid of its defects, but these processes were not sufficiently successful to get into general use. The authors have tried the principle of raising the temperature of ebullition of water by the presence of a dissolved salt; and for this purpose they employ chloride of calcium, which has the advantage of great cheapness, and is completely inert in the presence of the sulphur and its gangue at 120° C. The bath contains sixty-six per cent of the chloride, and serves for an indefinite period; the apparatus consists of two rectangular troughs, the dimensions of which vary according to the importance of the mine. One furnace serves for both, and they are used alternately, the boiling liquid being allowed, on the completion of the operation (which takes about two hours), to run from the trough used into the other one, which has been previously charged with mineral. The work thus goes on without interruption. The advantages of this process are said by the authors to be,—very cheap extraction of the sulphur from its gangue (five francs per ton), great purity of the sulphur produced, applicability throughout the year,* as there is no production of sulphurous acid, and almost complete extraction, the residue of sulphur in the gangue being not more than 2–3 per cent.

GEOLOGY AND PALÆONTOLOGY.

Mesozoic Rocks in Japan.—Dr. D. Brauns and Dr. E. Naumann have laid before the German East-Asiatic Society, which has its residence in Yokohama, a statement of the evidence that they have respectively obtained as to the occurrence of Jurassic and Cretaceous deposits in Japan. Dr. Brauns cites two Ammonites which he regards as Jurassic; one of them, identified by the author with *Stephanoceras coronatum*, was obtained from the province of Uragawa Gori, on the island of Jezo. Dr. Neumayr remarks that as the specimens show strong constrictions, and a different arrangement of the sutural lobes, the above identification cannot be correct; and from these and other characters he is inclined to think that it is an *Olcostephanus* of the group of *O. Astierianus* or *bidichotomus*. Nearly allied species of this type occur in South Africa (*O. Baini*, Sharpe), Thibet (*O. Scheutei*, Opp.), and Siberia (*O. polyptychus*), and a new species from the Hilsthon of North Germany (*O. Keiserlingi*) is the nearest European form. The second supposed Jurassic Ammonite is identified by Dr. Brauns with *Peltoceras athleta*, but this determination seems to be doubtful. Its origin is unknown; it was found in a worked stone in Tokio, brought from the town of Sendtrú. As the Japanese origin of the first-named specimen is also uncertain, this evidence of the occurrence of marine Jurassic deposits in Japan cannot be regarded as very satisfactory.

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* The Italian law only permits the fusion of sulphur by the 'Calcaroni' during about half the year, from the end of June to the 15th February.

With regard to the presence of Cretaceous rocks in Jezo, the case is different. The statements of Dr. Naumann relate to a series of Cephalopoda collected in that island by B. S. Lyman, including sixteen species, seven of which can be identified with certainty with previously described forms. The evidence thus furnished, and the general character of the species, indicates a close agreement with the fauna of the Upper Cretaceous of Southern India, as described by Forbes and Stoliczka, which includes all the above-mentioned seven described forms. The species from Jezo are as follows:—

Lytoceras Sacya, Forbes.
Phylloceras, n. sp. (allied to *Indra*, Forb.).
(? *subalpinus*, Orb.).
Velledæ, Mich.
Amaltheus Sugati, Stol.
Haploceras, n. sp.
planulatum, Forbes.
Gardeni, Baily.
Stoliczkaia, sp.
Anisoceras tenuisulcatum, Forbes.
sp.
n. sp.
Ptychoceras gaultinum, Pict.
n. sp.
n. sp.

According to Baily and Griesbach, this horizon is similarly developed in South Africa; and it would appear that the Cretaceous formation of Sachalin, described by F. Schmidt, is connected with that of Jezo, so that, in all probability, we have to do here with a continuous marine province of the Cretaceous period, surrounding the whole southern and eastern border of the African and Oriental continent.

Of the above species, three, namely, *L. Sacya*, *Ph. Velledæ*, and *Pt. gaultinum*, are cited by F. Schmidt from Sachalin, and the fourth recorded Ammonite from that island (*Haploceras peramplum*, Mant.), is considered by Dr. Naumann to agree with his supposed new species of that genus. (*Neues Jahrbuch*, 1881, Band ii.)

The Oldest Flowering Plants.—Count de Saporta and M. A. F. Marion recently brought before the French Academy of Sciences a joint memoir on the genera *Williamsonia* and *Goniolina*, the most ancient forms of flowering plants of the fructification of which anything definite is known. In *Williamsonia* the trunk bears at its extremity the organs of reproduction, which show two distinct forms, apparently indicating that the plant was diœcious, but in both there is a multifoliate envelope, which acquires a globular form by the curvature of the bracts composing it.

The parts of the envelope of the male flower seem all to stand at the same level: they are elongated, narrowed, and bent towards each other at the apex. Within the envelope rises a conical axis, the base of which is surrounded by a circular zone, with radiating striæ. The outer margin of this zone, when exposed, is found to be covered with a number of very small irregularly hexagonal areas, which seem to represent so many pollen-cells.

This basal zone would seem to represent a sterile and persistent part of the androphore, in which at one time the whole conical body was covered with a felted layer, composed of the filaments and their appendages, reminding one by its position and arrangement of the male flowers of the Reed-mace (*Typha*).

The female inflorescence of *Williamsonia* is furnished with a globular envelope like that of the male flowers, but its bracts are a little shorter. The organ contained in this envelope, and which is certainly deciduous when mature, consisted of a convoluted (?) receptacle of more or less globular form. The central leaves of the envelope, which have remained in place, testify by their thickness and leathery texture to the primitive nature of this formation. In their midst stands the globular conceptacle, the upper parts of which are covered with carpellary areas; and in the lower part of the receptacle we see the fibrous, woody tissue of which the axis was composed.

The remains of the genus *Goniolina*, D'Orbigny, appear as ovate bodies, in the form of cones rounded at the upper end, and borne upon a cylindrical stalk. The surface is covered with very regular hexagonal areas, arranged in spiral lines. The areas are smaller towards the point of insertion of the stalk. These fossils were formerly regarded as Echinoderms, and described as Crinoids under the name of *Goniolina geometrica*. (*Comptes Rendus, May* 23 and 30, 1881; *Kosmos*, 1881, Vol. IX.)

Trilobites.—Some ten years since Mr. Billing and Dr. Henry Woodward announced the discovery of jointed limbs in a species of *Asaphus*, and Mr. C. D. Walcott has since devoted much careful labour to the investigation of the structure of another Trilobite, *Calymene senaria*, of which he was able to obtain a great quantity, in a wonderful state of preservation, from a part of the Trenton Limestone. By cutting thin sections of these Mr. Wallcott has been able to demonstrate the existence in them of regular walking feet, and also to ascertain the number and character of all the limbs, so as to reconstruct the lower surface of the animal. It appears that the Trilobites, from the absence of antennæ, and the nature of the anterior pairs of limbs, belong to the class Pœcilopoda, now represented only by the King-crabs, but that they form a distinct group in the class. They differ from the extinct Eurypterida, as also from the Xiphosura (King-crabs), living and fossil, by the possession of *four* pairs of walking feet surrounding the mouth, and also by the presence *on each thoracic and abdominal segment of a pair of walking feet, furnished with branchial appendages.*

MINERALOGY.

Characters of some important Minerals.—The results obtained by the more exact methods of investigation employed in Mineralogy of late years have led to the change of a considerable number of minerals to systems of a lower grade of symmetry than those to which they had previously been

assigned. The classical memoir of Mallard (*Ann. des Mines*, Vol. X. 1876) had a strong influence in this direction. In it he sustained this change for some of the best-known species, and some of those which had been accepted as types of the systems to which they were referred,—such as garnet, vesuvianite, fluorite, apophyllite, zirkon, apatite, beryl, tourmaline, &c. In explanation of cases like those of just named, Mallard suggested the hypothesis that such crystals were to be considered as twins or compound-crystals, so made up as to have a pseudo-symmetry corresponding to a higher grade than that belonging to the individuals themselves.

The question as to the sharpness of the line dividing the crystalline systems from each other, and in many cases as to the system to which a given crystal really belongs, cannot be said to be decided at the present time. It is certainly possible to exaggerate the 'optical anomalies,' and to attribute to them a morphological significance, when they are, in fact, due simply to accidental causes, such as the internal tension produced at the time the crystal was formed. For example, the species boracite, long regarded as a typical hemihedral form in the isometric system, although with an anomalous optical character, which was variously explained, has been referred, by Mallard and others, to the orthorhombic system. Recently, however, Klein (*Neues Jahrb.* 1881) has shown, by the effect produced upon the optical character by heating sections of the crystals, that the peculiarities are probably due to internal tension simply, and that there is nothing which really conflicts with its being referred to the isometric system. Similarly analcite, the common form of which was long held to be a typical example of an isometric trapezohedron, was afterwards referred to other systems by Schrauf, Mallard, Lasaulx, and others, and finally referred back to the isometric system by several mineralogists, who have arrived at the same result by somewhat different methods. Other similar examples might be given.

M. Bertrand, working from the standpoint of M. Mallard, has recently published some interesting contributions to this subject. He shows that the apparently isometric octahedrons of ralstonite exhibit two optic axes, with an angle of about 90°. He has also examined a series of minerals, ranging from the pure lead phosphate, pyromorphite, to the lead arsenate, mimetite; and his conclusion is that while the first is truly hexagonal, and has a negative optic axis, the other is really orthorhombic, and owes its apparent hexagonal form to twinning. A section of mimetite from Johanngeorgenstadt, cut normal to the vertical axis, was seen in polarized light to be made up of six triangles, each having as base the side of the hexagon; the two optic axes make an angle of 64° in air. Between the two extremes there are various intermediate compounds containing both P_2O_5 and As_2O_5, and it is found that as the proportion of As_2O_5 diminishes, the angle of the optic axes also diminishes. Similar results have been obtained by M. Jannettaz. These facts recall the results obtained with crystals of iodide of antimony by Cooke, who proved the existence of a uniaxial (hexagonal) and a biaxial (orthorhombic) variety, of which the latter changes into the former on a slight elevation of temperature. M. Bertrand has also studied several varieties of garnet, and arrived at essentially the same results as M. Mallard. Sections of crystals of aplome, ouvarovite and topazolite show two optic

axes, with an angle of about 90°. Ouvarovite is regarded as made up of twelve pyramids, having the faces of the crystal as their base, and their vertices at the centre. The dodecahedrons of aplome and topazolite are explained as formed of forty-eight simple crystals. Further than this, M. Bertrand found it possible to separate the dodecahedrons mechanically into these forty-eight individuals, each one of which is truly biaxial; the fracture-surfaces are smooth and make angles of 60° with the rhombic faces, when the plane of separation obtained is parallel to the side of the rhomb, and of 90° when it is parallel to one of the diagonals. The former fractures are obtained more readily than the second, and it is concluded from this that the union of the four crystals which form together the same rhombic face is more intimate than that of the twelve complex rhombohedral pyramids among themselves. That this is the true explanation of these facts may perhaps be questioned.—(*Amer. Jour. of Sci.*, August, 1881.)

PHYSICS.

The supposed Heating of Ice.—Dr. A. Wüllner has repeated, by means of a modified form of apparatus, some of the experiments described by Mr. Carnelley (see *Pop. Sci. Review* for April, 1881). He finds that *so long as the bulb of the thermometer is completely surrounded by dry ice, its temperature does not reach* 0° C. If the thermometer rises higher, either the bulb is no longer quite covered with ice, or it is surrounded by water together with a thicker layer of ice. In other respects the course of the experiment was exactly as described by Mr. Carnelley. When the bulb becomes partially bare of ice, the thermometer will rise even to 50° before the ice becomes detached, and rapid heating would probably cause it to rise considerably higher. The detached ice, when it comes in contact with the hot glass, dances about like Leidenfrost's drops.

In order that fusion may not take place, the ice must not be too thick, but how thick was not determined. In one experiment the bulb was surrounded by a coating of ice from 1 to 1·5 centimetre thick, and strongly heated by the flame of a Bunsen's burner; the temperature rose quickly to 0°, when fusion commenced, *not on the surface, but in the centre of the ice, and in such a way that the water was forced out through the surface in small drops, like blisters,* and these, on the removal of the lamp, instantly froze. By heating again and again, the same phenomenon was repeated several times.

In a quantitative experiment, 75 grammes of ice were kept under low pressure and exposed to the temperature of steam from boiling water for five hours; no fusion occurred, and 42 grammes of ice were volatilized into the condenser.—*Ann. Chim. Phys.* xiii.; *Journ. Chem. Soc.* No. 226.

ZOOLOGY.

Origin of the Ova in the Hydroids.—The first idea of what is commonly known as 'Alternation of Generations,' was suggested by the phenomena presented by certain hydroid polypes, in which the sexual functions seemed to be performed by special zooids, which, indeed, were often cast free in the medusoid form, so that the distinction into sexual and agamic zooids appeared in these cases particularly clear. Some recent observations indicate that we may have to modify our views as to the phenomena presented by these animals. According to M. Goette, the ova of the *Hydrella* attain their complete development in the stem of the polype; and according to M. Weismann, the several elements are developed in the stem and afterwards passed into the gonophores in *Plumularia echinulata;* and the ova follow the same course in species of the genus *Eudendrium.* M. A. de Varenne (*Comptes Rendus,* 16th August, 1881) adds some further particulars bearing in the same direction. He finds that in *Campanularia flexuosa* the ova occur in the endoderm of the stem before any gonophores have made their appearance, and that they are simply endodermic cells differentiated, the cells being found in all stages of modification. The gonophore is at first a mere diverticulum of the wall of the polype, into which both ectoderm and endoderm pass, carrying with them the cells which have been transformed into ova. The same phenomena were observed in a variety of *Plumularia echinulata* met with at Roscoff, and in *Sertularia pumila.* Thus in these three species in which the sexual generation is represented by permanently attached gonophores, the ova are not developed in the gonophore but in the stem of the supposed agamic generations.

In *Gonothyræa Loveni* the medusiform gonophores do not become detached from the polype; the ova also originate from the cells of the endoderm within the stem, and are carried with the neighbouring tissues into the blastostyle and gonophore, completing their evolution in the undetached semi-medusæ.

In the Tubularian *Podocoryne carnea* and the Campanularian *Obelia geniculata,* which give origin to free-medusæ, M. de Varenne observed a similar sequence of phenomena. He found that in the region from which the medusæ are to bud, ova are produced by the modification of the cells of the endoderm. When the medusæ begin to bud they are at first simple diverticula of the two layers forming the wall of the polype, and the ova are carried with them into young buds; they are at first very small, but are rapidly developed, and attain their maturity after the medusa has been cast off. M. de Varenne sums up his results as follows:—

'We are thus led to conclude,—1. That in the species above cited, in which the sexual generation is represented by gonophores persistently attached to the hydroid polype, or by semi-medusæ, or free medusæ, the ova originate in the interior of the polype itself, and not in these gonophores or medusæ.

'2. That the ova are only differentiated cells of the endoderm, and that in them may be observed all the stages of transition between an ordinary endodermic cell and a fully developed ovum.

'3. That the ova are conveyed into a bud, which is at first only a diver-

ticulum of the wall of the polype; and that this bud enlarges and finally becomes a gonophore destined to be always attached, or a semi-medusa or free medusæ.

'4. If we accept as demonstrated the facts just put forward, the gonophores, the semi-medusæ, and medusæ cannot be regarded as sexual individuals, and consequently it would seem that we cannot assume an alternation of generations in these species.'

Geographical Distribution of the Eared Seals.—Following up the ideas put forward by Milne-Edwards with regard to the influence of marine currents upon the geographical distribution of the Penguins, M. E. L. Trouessart has applied the same principles to the investigation of the Eared Seals (Otariidæ), and his results confirm those arrived at by Milne-Edwards. In the present epoch the Eared Seals, like the Penguins, seem to be native to the Antarctic lands, whence they have spread towards the north. They are conveyed northward on the blocks of ice which the regular currents detach and carry away from the great southern glaciers, and in this way have colonized all the southernmost coasts of both hemispheres. In the west, Humboldt's current has carried them, with the Penguins, as far as the Galapagos Islands, situated under the Equator; but, unlike the Penguins, the Otaries also occur north of the Equator, being found on the shores of California and in the northern part of the Pacific, but M. Trouessart concludes that the northern Eared Seals did not arrive at their present haunts by the direct route, seeing that there is a distance of more than twenty degrees between the Galapagos and their Californian habitat; and further, *those of the Galapagos and California belong not only to distinct species, but to different genera.*

By investigating the currents of the ocean and noting all the stations at which Eared Seals are met with, M. Trouessart arrives at the conclusion that the absence of these animals from the stretch of coast above indicated is due not to the higher temperature of the tropical regions, but to the action of contrary currents. The equatorial current of the Pacific north of the Galapagos, and that of the Atlantic north of the Falkland Islands, are directly opposed to the northward migration of the Eared Seals. In the Atlantic, those which have reached as far as Tristan d'Acunha and then attempted to advance in the direction of the west coast of Africa, have been carried westward by the equatorial current and driven to the coast of Patagonia. The Eared Seals of the Cape of Good Hope have been prevented from advancing along the eastern coast of Africa by the Mozambique current. Hence Eared Seals are absent from the Atlantic Ocean north of the Falklands, and from the whole western part of the Indian Ocean, having only the eastern part of the latter for their migration into the Northern hemisphere.

Having reached the shores of Australia, the Otaries gradually advanced up the western coast, which they still inhabit, reaching in the north to Melville Island, off Port Essington, where at least two species are found. A secondary current, the direction of which is determined by the Monsoon, puts the Indian Ocean in communication with the Chinese Sea, and from April to October, or exactly at the time the Eared Seals come up towards the north, this current flows towards the north-east into the great basin of the Pacific. It must have facilitated the migrations of the Seals, which took place through the passages of the Molucca Sea, or by the broader and deeper course of the

Straits of Macassar. Once in the Chinese Sea, they would soon reach Japan; and thence, by the help of the great current of Tessan (the 'Black River' of the Japanese), they would easily make the tour of the North Pacific along the shores of Kamtschatka, the Aleutian Islands, and North America, as far as the south of California.

M. Trouessart considers that the genus *Zalophus* furnishes a proof of this migration,—it occurs on both sides of the Equator, namely, at Melville Island, Japan, California, and throughout the northern part of the Pacific.

Currents have probably acted an important part also in the dispersion of other forms of Seals,—thus a species of the genius *Pelagius*, generally considered almost peculiar to the Mediterranean, has lately been detected in the West Indies; and M. Trouessart remarks that the Monk Seal (*Pelagius monachus*) of the Mediterranean is known to pass out through the Straits of Gibraltar and to occur on the north-west coast of Africa, and as far as Madeira and the Canary Islands, so that some individuals of this species may easily have got caught by the equatorial current and carried away to the West Indies, where they have given origin to a new form (*Pelagius tropicalis*).

Macrorhinus is the only genus of true Seals occurring on both sides of the Equator, and Mr. Allen places the starting-point of this type in the Northern hemisphere. M. Trouessart remarks that the genus is only found there now at one point on the Californian coast, while it abounds on all the shores of the Southern hemisphere, and he is inclined to place the head-quarters of the type about the Island of Juan Fernandez, which is now one of their principal stations, and to assume that they were carried by the oceanic currents through a long *détour* by the Polynesian Islands to California.—*Comptes Rendus*, May 9th, 1881.

Mollusca and Vermes.—At the close of an investigation of the embryology of the Pulmonate Mollusca (*Archives de Zoologie Expérimentale*, 1880), M. Hermann Fol indicates certain conclusions at which he has arrived with respect to analogies existing between the Mollusca and Vermes. He regards the larvæ of the Mollusca as comparable only with the cephalic portion of the larvæ of Annelids, or with an entire Rotatorian. The Mollusca are not, in his opinion, segmented animals whose segments have been subsequently fused together, but animals that remain simple and never present even a rudiment of the metameric budding of the Annelids; whilst Rabl considered that there was an analogy between the very young Molluscan larvæ and a worm with three metameric larvæ. In conclusion, Fol remarks how greatly all recent investigations are in favour of the re-establishment of the Linnean class of Vermes. He thinks that the general result of recent embryogenic researches tends to the establishment of three great divisions of animals:—(1) the Vermes, Bryozoa, Brachiopoda, Mollusca, and Echinodermata; (2) the Arthropoda; (3) the Chordonia (Tunicata and Vertebrata).—*Kosmos*, 1881, Band ix.

Olfactory Organs of Insects.—M. Gustav Hauser has investigated this subject (*Zeitschr. für wiss. Zool.*, vol. xxxiv. p. 367), and arrived at the conclusion that the sense of smell in insects is seated in the antennæ. Glass rods moistened with oil of turpentine or acetic acid were presented to a great number of insects, which showed very clearly their perception of these

strong-smelling substances, by moving their antennæ and turning sharply round. But when their antennæ had been previously removed, the same insects gave no signs of perception, even when they were placed quite close to the turpentine or acetic acid. Flesh flies, from which the third joint of the antennæ had been cut away, were no longer attracted by the putrid meat, for which they had previously shown great fondness; they flew about as before, but no longer scented the meat from a little distance. Enveloping the antennæ with a thin coating of paraffin produced the same effect.

M. Hauser made an anatomical investigation of the antennæ, and came to the conclusion that 'the olfactory organ consists in insects, *i.e.* in all the Orthoptera, Pseudoneuroptera, Diptera and Hymenoptera, and also in a great part of the Lepidoptera, Neuroptera and Coleoptera,—1. Of a large nerve, originating from the cerebral ganglion and running into the antennæ of these animals; 2. Of a perceptive terminal apparatus, formed of bacillar cells, derived from the hypodermis, with which the fibres of these nerves are connected; 3. Of a supporting or auxiliary apparatus, which is formed by pits or cones filled with serous fluid, which are to be regarded as simple diverticula of the epidermis.'

It was ascertained that the organ was most highly developed in those insects which employ it in seeking after their food. The greatest number of olfactory pits and cones occur in wasps and bees; thus the hive-bee has 14,000–15,000 pits and about 200 cones on each flagellum. The saw-flies have a much smaller number. The flesh-flies and dung-flies also have 60–150 pits on each antenna; while in the flies which live on plants each of those organs has only 2–5 pits. In general the males have the olfactory organs more strongly developed than the females. (*Kosmos*, 1881, Vol. IX.)

The Ink of the Cuttle Fish.—M. P. Girod has communicated to the French Academy (*Comptes Rendus*, 11th July, 1881) the results of an investigation that he has made of the ink of the Cuttle-fish (*Sepia officinalis*). This fluid has no odour, but is of a slightly salt taste, and has an alkaline reaction. Under the microscope it shows, floating in a transparent serum, a multitude of excessively minute corpuscles, which, when put into fresh water, exhibit distinct Brownian movements. M. Girod finds the ink to consist of:—

Water		60 per cent.
Mineral substances . .	8·613	
Insoluble organic matter .	30·536	40 „
Extractive matter . .	0·851	

The *mineral substances* obtained by calcination constitute a pure white ash, which proved to contain lime, magnesia, soda, potash, iron and carbonic, sulphuric and hydrochloric acids. No phosphoric acid was present.

The *pigmentary matter*, after purification by a long series of operations and drying at 100° C., formed a black powder with a greenish metallic reflection, insoluble in water, alcohol and ether, insoluble in acids and in alkalies. Two analyses gave the following amounts of carbon, hydrogen, and nitrogen:—

	I.	II.
C	53·6	53·2
H	4·04	4·02
N	8·6	8·6

Mortality of Fish in the Gulf of Mexico.—Several notices in the *Proceedings of the United States National Museum* describe a very serious mortality that has occurred during the last two years among the fish of some parts of the Gulf of Mexico, near the coast of Florida, and the evidence would seem to show that it is due to some peculiar condition of a belt of water at a small distance from the shore. A Mr. M. A. Moore, writing from Braidentown, Manatee County, Florida, to Prof. Spencer F. Baird, on the 30th November last, gives a general account of the phenomena which had come under his observation. He says that a considerable portion of the coast population of South Florida depends mainly upon a fishing industry carried on by well-smacks of from thirty to fifty tons, in which the fish are conveyed alive to the Cuban markets. Some two years before the date above given, some portions of the water in the Gulf acquired poisonous properties, which caused the death of all the fish that came in contact with it. 'Whenever a smack with a full fare, *i.e.* a full cargo, of fine healthy fish in her well sailed into this poisoned water, every fish would die, and they would have to be thrown away. This compelled the vessel to return to fishing at the loss of a month's hard work.' This very serious state of affairs has continued ever since, sometimes in one place, sometimes in another, the poisonous influence, whatever it may be, affecting certain localities and currents for a time and then appearing elsewhere; but according to Mr. Moore, there was, when he wrote, more of it about the mouth of Charlotte Harbour and off Punta Russa than anywhere else. Where it prevails, the surface of the water is covered with dead fish, and they are often thrown up on the beach in such numbers that the stench becomes intolerable. The so-called 'bottom fish' appear to be more affected by the poison than any others. The grouper (*Serranus nigritis*) and the snapper (*Serranus erythrogaster*) are the principal fish taken by the fishing-smacks, and these, with the perch, kingfish, trout, and other fish that take the hook, are more affected than the mullet (*Mugil lineatus*) and the pompano (*Bothrolœmus pompano*). Numbers of sharks, rays, eels, and catfish, are thrown up dead upon the beach.

By other writers, the noxious water is said to be distinguishable by its colour, which is sometimes brick-red, and it is described as extending for a distance of 200 miles. The cause of this poisonous condition of the water seems to be very obscure. Some people, including the Mr. Moore above quoted, are inclined to believe that it is due to volcanic action at the sea-bottom, or to an escape of noxious gases, or of mineral substances held in solution; and the editor of a local newspaper (*Forest and Stream*) refers particularly to a boiling spring which is said to exist somewhere off the coast. Others suggest the presence of parasitic plants, and in this view Dr. F. M. Endlich, who has made an analysis of the noxious water, appears to agree. Dr. Endlich reports as follows upon the characters of the noxious and wholesome water, the former under A, the latter under B:—

	A.	B.
Specific gravity	1·024	1·022
Solid constituents (total) per cent . .	4·0780	4·1005
Ferric compounds, per cent . . .	0·1106	0·0724
Injurious organic matter . . .	ratio=3	ratio=2

The water A contained a large quantity of Algæ and Infusoria. (*Ann. Mag. Nat. Hist.*, September, 1881.)

The Egg-cases and Young of the Mantidæ.—M. C. Brongniart brought with him from Algeria some of the curious egg-cases formed by the species of the genus *Mantis*, and has communicated to the French Academy the results of his observations on their structure and on the hatching of the eggs (*Comptes Rendus*, July 11th, 1881). He says that the structure of these egg-cases (*oothecæ*) differs but little in the different species; they are attached to the branches of shrubs and to stones, and are generally pear-shaped, with the smaller extremity upwards. Externally they appear to be strongly furrowed transversely, and if cut through in the direction of these furrows, show a circular central chamber containing the eggs, surrounded by a sort of frothy envelope. Each egg-case consists of about twenty storeys of chambers, and each of the external furrows represents a storey; each storey of the central chamber is divided into two cells by a thin antero-posterior partition, and communicates in front with the outside world by a sort of flattened neck, the edges of which, in the form of scales, are bent and laid one over the other. Each of the central cells contains about a dozen eggs, so that there are about twenty-four on each storey; and the eggs are arranged symmetrically, so that the portion of the egg which will constitute the apex of the abdomen is towards the outer wall of the case, while the part representing the head is turned obliquely forwards, and the whole of them are brought close together. Owing to this arrangement, the larvæ, when hatched, merely have to push straight forward in order to escape from the case. Each egg is contained in a sort of gummy cell.

In the construction of the egg-case the insect employs its abdomen and elytra. The female Mantis clings to a branch, and then exudes a sort of frothy, somewhat transparent liquid, which it holds up by means of the extremity of its elytra. Of this it constructs the first storey of its egg-case in the form of a spherical hood, the business being effected by the abdomen, which kneads the frothy substance and spreads it in successive layers with the assistance of the cerci. The eggs are expelled from the abdomen together with a small quantity of the frothy liquid, which serves to form the cells in which they lie.

Soon after impregnation, which generally takes place in September, the female builds her egg-case and deposits her eggs, which hatch out in May and June, and each young larva, while still quite soft, advances towards the aperture of its cell in order to issue from it. M. H. de Saussure gives the following account of the emergence of the larva. He says:—'The little larva has now to escape from the cell in which it is enclosed, and, *as it is too weak to make use of its feet*, nature comes to its assistance by means of a peculiar contrivance. The surface of its body is clothed with a chitinous substance, upon which are developed some spines directed backward. By

giving its abdomen an undulating movement, the spines serving as a support against the walls of the cell, the larva travels towards the operculum in the same way that an ear of rye, by means of its spiny beards, can travel over a piece of cloth which is set in vibration.' M. Brongniart says that the spines are not upon the abdomen itself, but upon the cerci, or caudal appendages, which constitute two large mamillæ. The legs are also covered with spines which assist the larva in its movements. The larvæ of the upper part of the case are the first to issue, although these eggs are the last laid. On escaping from the egg-case, the young larvæ, instead of dropping to the ground, are suspended in the air by means of two long silken threads, attached by one end to the cerci already mentioned, and by the other to the inner wall of the egg-case. In this way, when all have emerged, they form a sort of bunch, and they remain thus for some days until their first moult takes place, when they leave their cast skins suspended from the case. (*Ann. Mag. Nat. Hist.*, August, 1881.)

Rhizopods, Food for Fishes.—Prof. Leidy reports that the young of some of the suckers (Catostomidæ), such as *Hypentelium*, *Myxostoma*, &c., have been found by Mr. S. A. Forbes, of Illinois, to have the intestines packed with tests of *Difflugia* and *Arcella*, indicating that they fed on Rhizopods. In a slide containing material from the intestines of a young mullet (*Myxostoma macrolepidotum*) from Mackinaw Creek, prepared by Mr. Forbes, Dr. Leidy distinguished *Difflugia globulosa* and *D. acuminata;* and in another of the food of *Eremyzon saccata*, he found *Difflugia globulosa*, *D. lobostoma*, *D. pyriformis*, *Arcella vulgaris*, and *A. discoides*, besides another peculiar undescribed form. (*Amer. Jour. Sci.*, July, 1881.)

Division of Englypha alveolata.—Prof. Gruber has described (*Zeitschr. für wiss. Zool.*, Bd. XXXV. p. 431) an exceedingly interesting process of division observed by him in the fresh-water Rhizopod, *Englypha alveolata*. The test of this elegant creature consists of little circular concavo-convex discs, covering the superficial layer of the sarcode-body. Similar little discs also exist in the interior of the body in the neighbourhood of the nucleus. When the sarcode-body begins to grow out of proportion to the test, a portion of the contents of the latter protrudes from its orifice, and gradually increases in bulk, and into it pass by degrees the little discs contained in the interior of the body, and group themselves into a structure resembling a fircone, which clothes the surface of the protoplasmic process. By the continued increase of the latter the little discs are pushed further and further apart, until this part acquires exactly the form of the original animal, of which there are then two, adhering together, with the orifices of their tests turned towards one another. It is only now that alterations commence in the nucleus, which still retains its original position. First of all, fine granules and twisted lines make their appearance in it; then it becomes extended in the direction of the long axis of the animal, whilst at the same time a distinct longitudinal striation becomes perceptible, in consequence of which the nucleus divides into two nearly equal parts; of these one passes over into the process, where, like the half remaining into the original position, it soon resumes a pale, nearly vesicular appearance. Now by a rapid circular flowing in the sarcode, a mixture of it takes place, the body draws back here and there a little from the test, and finally the two halves separate as two

perfect *Englyphæ*. Gruber attaches much importance to the fact that the separate portion grows into a complete animal before the original nucleus begins to divide, and regards this as furnishing further evidence of the correctness of Strasburger's opinion that the true seat of activity in cell-formation is not the nucleus but the protoplasm,—at any rate, as Gruber points out, his observations furnish a fresh proof that the nucleus of the Rhizopod is a typical cell-nucleus. He has since observed a similar process of division in the nearly allied genus *Cyphoderia*.

A New Species of Horse.—The *Annals and Magazine of Natural History* for July contains a translation of a Russian paper, in which M. Poliakof brings forward a mass of evidence in proof of the existence of a hitherto unknown species of horse, not far from Zaisan, in Central Asia. The animal appears to resemble a small domestic horse, of a dun colour; its head is large in proportion to the size of the animal; and the root of its tail is destitute of long hairs for some distance. M. Poliakof names his supposed new species *Equus Przewalskii*, in honour of the traveller who brought the skin to Russia. He regards it as a true horse, and remarks that 'if it were possible to prove that culture influenced the growth of the tail, and that this became more hairy, and the mane longer, under altered conditions of life,' it might be affirmed that 'it was indeed the animal whose ancestors were reclaimed by man in the stone period, the so-called domestic horse of our day.'

Deep-sea Pycnogonidæ.—The 'Sea Spiders,' dredged by the U. S. steamer *Blake*, during the summer of 1880, along the east coast of the United States, have been described by Mr. E. B. Wilson in the *Bulletin of the Museum of Comparative Zoology*. The deep-sea forms here, as elsewhere, are remarkable for their colossal size, compared with those of shallower water, and in a number of forms the eyes (*ocelli*) are either rudimentary and destitute of pigment, or altogether absent; while, on the other hand, in one genus, *Pallenopsis*, the eyes are unusually large. Mr. Wilson specially describes the morphology and innervation of the anterior appendages; upon which he remarks that 'it is easily possible that the external resemblance of a Pycnogonid to an Arachnid are those of analogy only, and have no morphological significance.' This is the more probable from the extreme variability of the three anterior pairs of appendages in position and structure.—*Amer. Nat.*, August, 1881.

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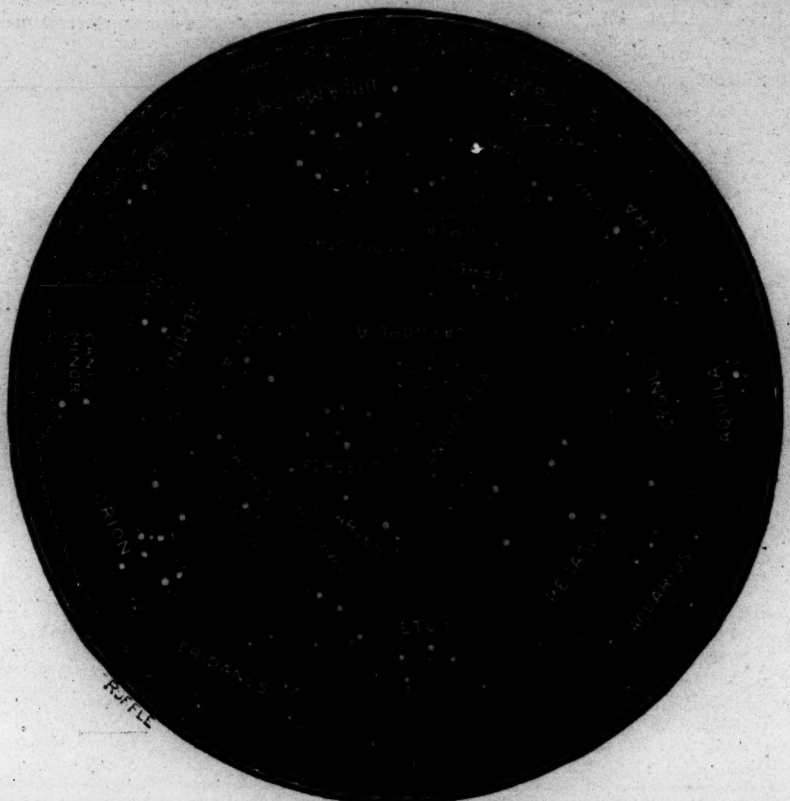

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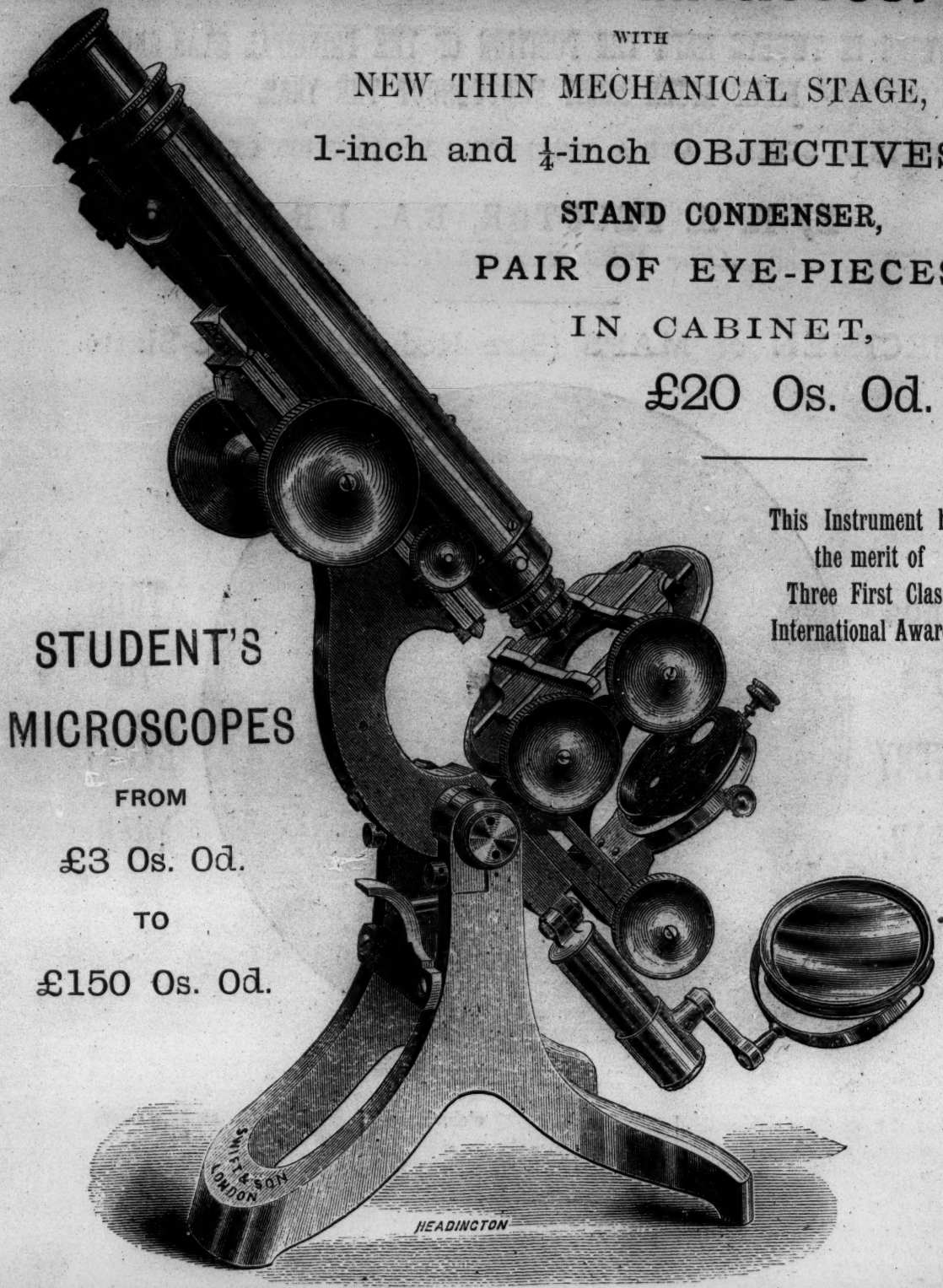

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